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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 600 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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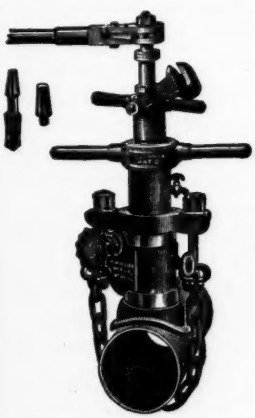

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NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

PRELIMINARY REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE, WITH DISCUSSION.

FREEMAN C. COFFIN,* F. F. FORBES,† AND DEXTER BRACKETT,‡ *Committee.*

[*Report presented December 11, 1901; the discussions printed herewith include all those received up to May 1, 1902.*]

MR. FREEMAN C. COFFIN. Before reading this report, I will say that we hope that the report, or at least the specifications accompanying it, will not be considered by you as in their final form. The Committee, although it has met some of the representatives of the manufacturing interests, and also some others who are particularly interested in this subject, has not been able, even yet, to consider the matter in connection with others, and to discuss the points as it would have liked to do, simply on account of lack of time and press of other business. The specifications as they are presented to you now embody the present ideas of the Committee, and are presented with the hope that there will be a thorough discussion of all the points, and that a final form of the specifications may be adopted in view of all the discussion and suggestions and criticisms which may be made; and your Committee also thinks it may be desirable for the Association to communicate with other bodies which are considering this subject at the present time. The Committee hopes that the specifications will be fully discussed and criticised, so that all the points may be brought up.

(Mr. Coffin then read the report of the Committee and the proposed specifications, as follows): —

BOSTON, November 22, 1901.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — In its consideration of this subject your Committee has assumed that it was your intention that its study should cover

* Civil Engineer, Boston, Mass. † Superintendent of Water Works, Brookline, Mass.
‡ Engineer Distribution Department, Metropolitan Water Works, Boston, Mass.

the design of cast-iron pipe and special castings, as well as the methods of their manufacture, and that its recommendations should include drawings of the pipes and special castings, tables of dimensions, and a list of weights for the different diameters and classes, in addition to specifications of the processes of manufacture and the character of the pipes when completed.

The Committee has conceived its duty to be not the recommendation of new processes, radical changes in existing specifications, nor even an unvarying list of weights for different heads or pressures, but rather a codification of the best present practice in design and manufacture in such form that, if used as a standard, pipe can be furnished by the manufacturers and procured by purchasers with more certainty of satisfaction than can be done at present, even with the most perfect individual specifications, and at the same time to be sufficiently elastic to allow, with a minimum of trouble, the incorporation of special ideas in an order for pipes.

It is believed that standard specifications to obtain general acceptance must allow for the personal equation of the user. While the many difficulties attending the present individualistic methods are well known, the Committee recognizes the futility of the adoption of a standard which, although securing uniformity, too closely limits individual freedom of practice.

The specifications recommended will not be wholly satisfactory to those who hope for an instrument which will of itself, without further thought or study, automatically regulate the whole business of securing suitable pipe for use under all conditions. The Committee believes, however, that it is practicable to arrange standards in such a manner that no one adopting them will be obliged to depart widely from his own practice, while at the same time many of the difficulties now attending the purchase and use of cast-iron pipes will be avoided.

SOME OF THE DIFFICULTIES OF PRESENT PRACTICE.

Form and Dimensions of Pipes and Castings. — The variation in form and dimensions of pipes and castings from different foundries, and even in different lots from the same foundry, causes much trouble and expense in pipe laying. Special castings are the most troublesome in this respect, spigots often being too large or thick to allow sufficient lead room in the bell of the pipe, even if they will enter at all without chipping the bead. Different classes of pipe

often cause trouble in the same way, especially when the different thickness of shell is secured by a change in the outside diameter.

Unless drawings are furnished for special castings (which it is not always practicable to do, especially for small orders), one does not know the length or weight, or even if the castings will come with bell and spigots, or bells all around. Sometimes reducers are sent with bells on the large end and sometimes on the small end. The radii of bends can rarely be ascertained in advance.

Even when drawings are furnished, unless an inspector is at the works, the castings are quite as likely to come of some other pattern and weight (not usually lighter), when the alternatives are to use those sent or wait for others to be cast and delivered.

On the other hand, it is clearly impossible for the manufacturer to keep a stock of pipe or specials on hand, when he cannot be sure that any two orders will have the same requirements, even in the simplest detail.

The entire lack of system in fixing the weights of pipes is the cause of much trouble and perplexity, the weight cards of the different foundries agreeing no better than the tables of different engineers. The great variety in specifications not only causes trouble in the foundry, but results to the purchaser of pipe not inspected at the works and of pipe in small lots or on quick orders, in the receipt of pipe which, although it may make fairly good work when laid, is nothing more nor less than a job lot of different sorts and sizes, very difficult to lay.

RECOMMENDATIONS.

In an endeavor to simplify and unify the practice in the manufacture and use of cast-iron pipes and special castings, your Committee makes the following suggestions, which are embodied in the appended *Standard Specifications for Cast-Iron Pipe*, which it recommends to the Association for adoption.

DESIGN.

Length. — The standard length of the pipes shall be 12 feet, exclusive of the bell or socket.

Diameters. — For sizes from 4 to 18 inches, inclusive, the inside diameter of pipes of a given nominal size shall be varied in accordance with the varying thickness used for different pressures or conditions, and the outside diameter for all classes or weights shall be

uniform. For sizes larger than 18 inches, there shall be three sizes for the outside diameter of each nominal diameter.

It is feared that if one outside diameter were adopted for all classes in the larger sizes of pipes, it would cause so much difficulty in connecting future pipe to that already laid, and in making repairs, that it would be a serious obstacle to the adoption of the standard. It is also believed that the use of more than one outside diameter will not cause so much trouble in the larger sizes as in the smaller ones.

The Committee has endeavored to suggest outside diameters for the several sizes of pipes that will conform as nearly as possible to sizes in general use at the present time, and, also, those which will give the full interior diameter for the thickest pipe in common use. The outside diameters proposed by the Committee are given in Table No. 1 of the specifications.

Depth and Joint Room of Bells. — There is undoubtedly considerable variation in present practice in the depth of bells. The Committee is of the opinion that good results are secured with all depths used, and that an exact depth of bell is not an essential matter to any engineer. Therefore, as the use of a standard bell will do much to simplify the casting of pipe, it recommends the adoption of the list of depths given in Table No. 1. These depths are believed to conform very nearly to the average practice.

Although the practice regarding variation in joint room is not as great as in the depth of the bells, the Committee was influenced by the same reasons to recommend a uniform list of thickness, which is also found in Table No. 1.

If Table No. 1 is adopted as the standard, and adhered to, the result will be that every pipe and special casting under 20 inches in diameter will fit every other pipe and casting of the same nominal size.

Thickness and Weight of Pipe. — In the classification of cast-iron pipe for different pressures and conditions is to be found a more serious divergence of opinion and practice than in any other branch of the subject. The Committee has not deemed it advisable to recommend the adoption of standard weights for stated pressures for the reason that the thickness or weight of the pipe to be used depends in many cases upon other conditions in addition to the static pressure. In pipes of the smaller sizes the thickness required depends upon the strength needed to withstand handling and the strains

due to the settlement of earth, and other causes, rather than upon the internal pressure. For this reason heavier pipes are required in city streets, where they are subjected to settlement from frequent excavations, than in country towns where they remain undisturbed.

Other conditions beside the pressure must also be considered in determining the thickness of the large sizes of pipe; for example, large pipes in public streets, where they may be subject to heavy loads, or in places where the depth of earth covering is great, should be made thicker than where laid in locations specially reserved for their use. The static head or pressure can be closely estimated, but the water hammer, effect of traffic over the pipe, settlement under it, tuberculation within it, electrolysis outside of it, and age everywhere, can, with present knowledge, be given no mathematical value. These conditions must, however, be taken into consideration in determining the thickness of pipe to be used in any given case.

It is probable that no formula exists which is a scientific expression of all these requirements — perhaps no such rational formula can be devised, certainly not until more definite data are secured for the various strains, both internal and external, which are sustained by pipes in use. It was finally decided to devise a table of thicknesses and weights based upon some logical formula, and to give the different weights an arbitrary classification denoted by a symbol such as a letter of the alphabet, in which the variation in weights from one class to another should not be so great that one would be unable to select pipes that would approximate his own practice and of sufficient range to cover all except the most extreme cases.

The thicknesses given in Table No. 2 were computed by the following formula, which is one used in determining the thickness of pipe used on the Metropolitan Water Works, which supply water to Boston and other cities and towns within a radius of ten miles; Class A being for a static head of fifty feet, Class B for one hundred feet, etc., each class advancing by fifty feet. This formula provides factors for the deterioration of the pipe by time and other conditions, for the internal strain due to the static head and to water hammer, but, as has been previously stated, other conditions must also be considered.

$$t = \frac{(p + p')r}{3300} + 0.25 \text{ in which}$$

t = thickness in inches;
p = static pressure in pounds per square inch;

p' = pressure in pounds allowed for water hammer;
r = internal radius of pipe in inches;
3 300 = 1/5 tensile strength of cast iron taken to be 16 500 pounds per square inch;
0.25 = allowance for deterioration by corrosion and other causes.

VALUES GIVEN TO P' AS FOLLOWS:

Diameter of Pipe.	*P' in Pounds.*
4, 6, 8, and 10 inch.	120
12 and 14 inch.	110
16 and 18 inch.	100
20 inch.	90
24 inch.	85
30 inch.	80
36 inch.	75
42 to 60 inch.	70

The Committee does not recommend the classification of the weights upon the basis of static head, believing that to the engineer or superintendent should be left the final decision as to the thickness or weight of pipe suitable for the particular place in which it is to be used.

Table No. 2, if adopted, will furnish a basis for pipe practice in which the classes will have a uniform meaning, and when used as the basis of an order will insure to the buyer the pipe which he intends to use. This will be a distinct improvement on present conditions under which a class letter has no meaning, except when accompanied by a statement of weight.

The table does not assume to fix the weight which shall be used for different heads or conditions of service. It is believed that the range is sufficient to provide for all usual conditions, and that the variation between one class and the next is not great enough to prevent the selection of weights that will closely approximate individual practice.

This uniform classification does not necessitate any radical departure from present foundry methods, yet it can hardly fail to be of advantage to the pipe manufacturer, especially in providing standard weights for stock pipe.

Special Castings. — In general design, the special castings recommended are of the pattern now used on the Metropolitan Water Works. A number of foundries have the patterns for these castings, and they are already in a fair way to become a standard.

The Committee is of the opinion that it would be difficult to improve upon these patterns. They are designed with the purpose of

putting as little metal into the special castings (where it costs about twice as much as it does in straight pipe) as is consistent with strength and convenience in laying.

As the specifications allow a margin for excess or deficiency in weight of not exceeding six per cent., abnormal excess of weight (a serious fault in many castings) is avoided, and the purchaser can estimate with reasonable accuracy the cost of the castings in advance.

The outside diameter and the openings of the bell or socket are the same as those of the pipes of the same size. There is but one class of special castings for all classes of pipe below twenty inches. It is hoped that the vexing occurrence of the necessity for chipping spigots of special castings to enable them to enter the pipe bells, which has heretofore been much too common, will be avoided by this uniformity.

Tables giving full dimensions and weights will accompany the specifications in their final form.

Manufacture. — The clauses of the specifications which refer to the processes of the manufacture of the pipe and castings are recommended by the Committee as representing in its opinion the best modern practice which has been tested by time and experience.

There are some points which are as yet unsettled, such, for instance, as the coating of the pipes. The Committee believes that the method specified is the most satisfactory one in general use. It recognizes, however, that improvement in this matter is to be desired. It is possible that some of the processes already suggested may prove to be better. They are yet in the experimental stage, and, therefore, not suitable subjects for recommendation. Even standard specifications must be subject to revision, as experience shows their requirements to be rendered obsolete by better methods. It is, of course, always open to the purchaser to substitute requirements of his own for any clause or clauses of the specifications or in addition thereto. The fact that he may often choose to do so does not impair the value of standard specifications.

In conclusion, the Committee will state that the specifications are recommended to the Association for criticism and amendment, if thorough discussion by all interested shows changes to be desirable.

Respectfully submitted,

FREEMAN C. COFFIN,
F. F. FORBES,
DEXTER BRACKETT,

Committee on Standard Specifications for Cast-Iron Pipe.

SPECIFICATIONS.

DESCRIPTION OF PIPES.

The pipes shall be made with hub and spigot joints, which shall accurately conform to the dimensions given in Table No. 1.

They shall be true circles in sections, with their inner and outer surfaces concentric.

The straight pipes shall be straight, and the curved pipes shall be true to the required curvature in the direction of their axes.

They shall be of the specified dimensions in internal diameter from end to end, and the straight pipe shall be twelve feet in length, exclusive of socket.

Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint-room from any cause. The joint-room for each class of pipe shall not vary more than .06 of an inch from the dimensions given in Table No. 1.

No pipe shall be accepted when the thickness of metal in the body of the pipe is more than .08 of an inch less at any point than the standard thickness given in Table No. 2.

The length of the pipe shall not be changed except by written permission of the engineer, and in case of such change the standard weight of the pipe given in Table No. 2 shall be modified in accordance therewith.

DEFECTIVE SPIGOTS.

Defective spigot ends on pipes twenty inches or more in diameter may be cut off in a lathe, and a half round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than six per cent. of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than eleven feet in length, exclusive of the socket.

SPECIAL CASTINGS.

All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The contractor shall furnish and deliver all bolts for

bolting on the manhole covers, the bolts to be of the sizes shown on plans, and made of the best quality of American refined iron, with hexagonal heads and nuts, and sound, well-fitting threads.

MARKING.

Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name, the year in which it was cast, and the class letter. When cast especially to order, each pipe and special casting shall also have cast upon it the number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below; thus: —

$$\frac{1901,}{1} \qquad \frac{1901,}{2} \qquad \frac{1901,}{3}$$

etc., also any initials, not exceeding four, which may be required by the purchaser.

The letters and figures to be cast on the outside, not less than two inches in length and one eighth of an inch in relief.

PERCENTAGE TO BE PAID FOR.

No pipe shall be accepted the weight of which shall be less than the standard weight by more than four per cent. for pipes 16 inches or less in diameter, three and one-half per cent. for 18-, 20-, and 24-inch pipes, and three per cent. for pipes more than 24 inches in diameter; and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe the sum of the standard weights for the same number of pieces of the given size and class by more than two per cent.

No special castings shall be accepted the weight of which is more than six per cent. less than the standard weight, and not more than six per cent. in excess of the standard weight shall be paid for.

QUALITY OF IRON.

The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace. It shall be of such character as to make a pipe strong, tough, and of even grain, and soft enough to satisfactorily admit of drilling and cutting.

Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 2 000 pounds, and show a deflection of not less than .35 of an inch before breaking. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

HOW CAST.

The straight pipes shall be cast in dry sand molds, in a vertical position, with the hub-end down, and the special castings in loam, except when otherwise permitted in writing, in either case, by the engineer.

The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

QUALITY OF CASTINGS.

The pipes and castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature. No plugging or filling will be allowed.

CLEANING AND INSPECTION.

All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped. The contractor shall provide a covered tramway from the casting-room to the dipping vat, so that no casting shall be liable to become wet previous to its being coated.

COATING.

Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit immediately before it is dipped, and shall possess not

less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahrenheit (or less, if the engineer shall so order) and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

HYDROSTATIC TEST.

When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows: —

Class	A	pipe,	150	pounds	per	square	inch.
"	B	"	200	"	"	"	"
"	C	"	250	"	"	"	"
"	D	"	300	"	"	"	"
"	E	"	350	"	"	"	"
"	F	"	400	"	"	"	"

They shall also be subjected to the same proof by water pressure and hammer test after their delivery and before their final acceptance, if required by the engineer.

WEIGHING.

The pipes and special castings shall be weighed for payment under the supervision of the engineer, after the application of the coal-tar pitch varnish, and the weight of each pipe and special casting shall be conspicuously painted in white on the inside, after the coating has become hard. If desired by the engineer, the pipes and special cast-

ings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement.

CONTRACTOR TO FURNISH MEN AND MATERIALS.

The contractor shall provide all tools, materials, and men necessary for the proper testing, inspection, and weighing at the foundry of the pipes and special castings; and if required by the engineer, he shall furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the transverse tests upon the test bars.

POWER OF THE ENGINEER TO INSPECT.

The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which in his opinion is not in conformity with the specifications or drawings furnished. He shall have the power to prevent the use of any metal, mold, or core which in his opinion may not be proper for the purpose for which it is intended.

CASTINGS TO BE DELIVERED SOUND AND PERFECT.

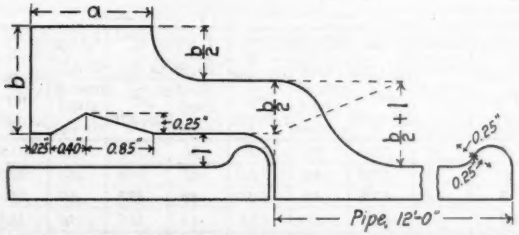
All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other casting which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

DEFINITION OF THE WORD "ENGINEER."

Wherever the word "engineer" is used herein it shall be understood to refer to the engineer, or inspector, acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.

Table No. 1

General Dimensions of Pipes and Special Castings.



Nominal Diam. Inches	Class	Actual Outside Diam. Inches	Depth of Sockets		Thickness of joint for calking.– Inches	"a"	"b"
			Pipe. Inches	Special Castings. Inches			
4	All Classes	4.90	3.00	4.00	.40	1.50	1.30
6	" "	7.00	"	"	"	"	1.40
8	" "	9.10	3.50	"	"	"	1.50
10	" "	11.30	"	4.50	"	"	1.50
12	" "	13.40	"	"	"	"	1.60
14	" "	15.50	"	"	"	"	1.70
16	" "	17.60	4.00	5.00	.50	1.75	1.80
18	" "	19.70	"	"	"	"	1.90
20	Classes A&B	21.30	"	"	"	"	2.00
"	" C-D	21.60	"	"	"	"	"
"	" E-F	21.80	"	"	"	"	"
24	" A-B	25.40	"	"	"	2.00	2.10
"	" C-D	25.80	"	"	"	"	"
"	" E-F	26.10	"	"	"	"	"
30	" A-B	31.60	4.50	"	"	"	2.30
"	" C-D	32.00	"	"	"	"	"
"	" E-F	32.40	"	"	"	"	"
36	" A-B	37.80	"	"	"	"	2.50
"	" C-D	38.30	"	"	"	"	"
"	" E-F	38.70	"	"	"	"	"
42	" A-B	44.00	5.00	"	"	"	2.80
"	" C-D	44.50	"	"	"	"	"
"	" E-F	45.10	"	"	"	"	"
48	" A-B	50.20	"	"	"	"	3.00
"	" C-D	50.80	"	"	"	"	"
"	" E-F	51.40	"	"	"	"	"
54	" A-B	56.40	5.50	5.50	"	2.25	3.20
"	" C-D	57.10	"	"	"	"	"
"	" E-F	57.80	"	"	"	"	3.80
60	" A-B	62.60	"	"	"	"	3.40
"	" C-D	63.40	"	"	"	"	"
"	" E-F	64.20	"	"	"	"	4.00

Table No. 2

Standard Thickness and Weight of Cast Iron Pipe.

12 feet in length exclusive of socket.

Nominal Diameter of Pipe Inches	Class A		Class B		Class C		Class D	
	Thickness of shell Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length
4	.34	200	.35	207	.36	212	.38	218
6	38	330	.40	340	.42	355	.44	370
8	.42	475	.45	500	.48	525	.50	550
10	.47	650	.50	685	.53	725	.56	765
12	.49	810	.53	865	.57	920	.61	980
14	.53	1010	.57	1085	.61	1155	.66	1230
16	.55	1215	.60	1310	.65	1410	.70	1500
18	.57	1410	.63	1540	.69	1660	.75	1790
20	.60	1610	.66	1760	.72	1920	.79	2080
24	.64	2050	.72	2290	.80	2530	.88	2770
30	.71	2860	.81	3230	.91	3600	1.01	3950
36	.79	3800	.90	4270	1.02	4830	1.13	5300
42	.87	4900	1.00	5560	1.13	6270	1.27	6970
48	.95	6130	1.10	6970	1.25	7900	1.40	8780
54	1.03	7510	1.20	8600	1.37	9800	1.54	10900
60	1.10	8900	1.30	10300	1.50	11900	1.70	13300

Nominal Diameter of Pipe. Inches	Class E		Class F		Class G	
	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length	Thickness of shell. Inches	Weight per Length
4	.39	225	.40	230	.42	240
6	.46	385	.48	400	.50	415
8	.53	575	.56	600	.58	630
10	.60	805	.63	845	.67	885
12	.65	1035	.69	1090	.73	1150
14	.70	1300	.75	1380	.79	1450
16	.75	1600	.80	1700		
18	.80	1910	.86	2040		
20	.85	2250	.92	2410		
24	.95	3000	1.03	3240		
30	1.10	4320	1.20	4680		
36	1.25	5900	1.37	6360		
42	1.40	7700	1.53	8350		
48	1.55	9740	1.70	10600		
54	1.72	12350	1.90	13500		
60	1.90	15100	2.10	16500		

DISCUSSION.

MR. COFFIN. As it is desirable to have a full discussion here by all who are interested, and as all who have received the advance copy of the report have been invited to discuss it either by letter or orally; and as there is, I believe, a clause in the by-laws or constitution which requires some action of the Association in relation to discussion by others than members, it may be in order for me to make a motion that this discussion be open to all who are interested in the subject.

Adopted.

THE CHAIRMAN. The matter is now open for discussion. I think we would like to hear from the other members of the Committee, and I will call upon Mr. Brackett.

MR. DEXTER BRACKETT. It seems to me, Mr. Chairman, that the Committee having presented its report, the members should now discuss the subject, and if any questions arise I shall be very glad to explain my position on the subject. The report of the Committee contains my ideas, subject to revision, as suggestions may be made by the members.

MR. EMIL L. NUEBLING* (by letter). The Committee on Standard Specifications for Cast-Iron Pipe has made a move in the right direction by recommending that the outside diameters shall be made uniform for all classes of pipes under twenty inches in diameter, and would not have been severely censured if this practice had been extended to include all sizes of pipes. Standard sizes, to be perfect, should not be burdened with several subdivisions, and so long as there are several standard sizes of pipe for one nominal diameter, the general adoption of the standard specifications will not take place. The benefits to be derived by the adoption of a single standard greatly outweigh the objections to it. If the standard outside diameter is proportioned by the formula given by the Committee (making p equal 120 pounds per square inch) it will conform to the bulk of the pipes in use at the present time. The objection made by the committee, that it would cause much difficulty in connecting future pipes to those already laid, can be readily overcome by the use of a casting of short length, having a standard spigot on one end and a bell or hub on the other end large enough to go over the old style of pipe. The benefits of a single standard are many, to manufacturers as well

* Engineer and Superintendent of Water Works, Reading, Pa.

as users. If a standard were in universal use, the manufacturers of pipe would be saved the expense of providing many different sizes of pipe patterns, and this might eventually result in the general introduction of the rotary mold ramming machine, which will give better workmanship at less cost. Manufacturers of gates, fire hydrants, and special castings will be equally benefited with the pipe manufacturers by using a single pattern for all bells and hub ends. The single standard will also save carrying a miscellaneous lot of gates and specials on hand, having different sizes of bell openings, in localities where all the different classes of pipes would be in use. A special or gate made for a 48-inch Class E pipe would not be used on a Class B pipe, because the lead joint would be 1.1 inches thick, which is entirely too large for good work; so, to be prepared for any emergency, several specials or gates of each nominal diameter above eighteen inches would have to be kept in stock if the multiple standard is used.

The standard thickness of joints for calking should be made as small as possible, having no greater thickness of lead than is absolutely necessary for proper pouring and calking of joints. The strength of lead joints varies directly as their thickness. A joint $\frac{1}{4}$ inch in thickness is as strong again as a joint $\frac{1}{8}$ inch in thickness, because the larger joint has so much more area exposed to the pressure of the water back of it. We have laid several thousand feet of 36-inch pipe with lead joints $\frac{3}{8}$ inch in thickness, and have had no leaks on this line since it was laid, several years ago; while a line of 24-inch and 30-inch pipes with joints of from $\frac{5}{8}$ to $\frac{3}{4}$ inch in thickness is giving us very much trouble from leaks caused by the lead joints pushing out. With the merit of small joints in mind, the following suggestion is made: That the thickness of joints for calking be made $\frac{5}{16}$ inch for all sizes of pipes from 4 inches to 20 inches inclusive, $\frac{3}{8}$ inch for sizes from 24 inches to 42 inches inclusive, and $\frac{7}{16}$ inch for sizes from 48 inches to 60 inches inclusive.

Mr. Frank A. McInnes* (by letter). I have read with pleasure the able report of the Committee on Standard Specifications; its adoption would prove a long step in the right direction, to the advantage of consumer and manufacturer alike. The requirement of a uniform outside diameter is a wise innovation in general practice; it was adopted by the Boston Water Department three years ago, and since that time there has been a gratifying absence of the necessity

*Assistant Engineer, Engineering Department, City of Boston.

of chipping beads, and abnormally large or small joints have disappeared. One criticism, perhaps a somewhat selfish one, suggests itself, viz., in regard to the depths of bell; those proposed are, in my opinion, too shallow for pipe which is to be laid in the streets of a city where the danger of disturbance and settlement is ever present: our streets are so filled with pipes, conduits, tubes, etc., of all kinds, that we are forced to depend upon "open joints" in addition to "specials," to solve some of our problems.

There are two possible additions to the specifications which I would like to suggest, for discussion at least. The first is the insertion of a clause regarding chemical analysis: this is a feature in specifications for steel and wrought iron — why not apply it to cast iron? My attention was particularly called to this point by a succession of breaks in a 48-inch line (laid in 1869) which could not be satisfactorily explained; a chemical analysis, made in the case of each break, conclusively stamped the iron as "bad." It is conceivable that test bars might not have condemned this iron, as they are not infallible, particularly when their pouring and cooling are not closely watched; the pressure test, too, might easily fail in the case of brittle iron. A requirement stipulating the composition of the metal would be getting at the very foundation; it, of course, would not take the place of the test bar, but it might be employed occasionally to great advantage, at any time before the final payment. The very fact of the existence of such a clause in the specifications would be useful.

The second suggestion is the desirability of requiring that certain castings, such as $\frac{1}{8}$ and $\frac{1}{16}$ bends, branches, reducers, hydrants, etc., be made with green-sand cores. The principal advantage in this method of casting is in the fact that chaplets are not used; the arbor around which the core is formed passes out through the flask, and is held rigidly in place without further assistance. I think it will be granted that the chaplet is apt to be the weakest spot in a casting — a collection of them made during the past summer from our junk pile would convince the doubter of this fact. Another advantage of the green-sand method is that it is easier to get smooth, uniform castings in this way than with dry-sand cores. The method is applicable to castings up to twenty inches in diameter at least. For the past year, the bends (except quarter turns), the branches, reducers, sleeves, etc., (under 24-inch), and the hydrants used by the Boston Water Department have been made in green sand with marked success.

There is a further inviting field for investigation, namely, the

actual structure of the iron as disclosed by the microscope and by photography. Before long we will have to consider this feature in our specifications.

Mr. Louis H. Knapp* (by letter). I approve of Tables No. 1 and 2 in every respect, and think it very desirable to have them adopted.

The following clauses from the Buffalo specifications may be of interest: —

4. All pipes shall be cast vertically, and shall be made in such molding sand or loam as will leave the surface in good condition to receive the coal-tar varnish.

5. The metal of which the pipes are made shall be iron, remelted in a cupola or air furnace, and of such make as shall be approved by the engineer.

It shall be without any admixture of cinder iron or inferior metal, entirely free from uncombined carbon, when seen under the microscope, and shall admit of being easily drilled or cut. The iron in the pipe shall have a tensile strength of at least eighteen thousand (18 000) pounds to the square inch.

I think some reference should be made to the quality of the sand; also, the tensile strength of the cast iron should be specified.

I would leave out the clause relating to defective spigots in the general specifications, and leave the question of defective ends to the engineer or inspector.

13. Every pipe shall be carefully coated inside and out with coal-tar pitch and oil, in accordance with the following rules: —

Every pipe must be thoroughly dressed and made clean, free from the earth or sand which clings to the iron in the mold.

Every pipe must be entirely free from rust and dust when the coating is applied. If the pipe cannot be dipped immediately after being cleaned, the surface must be oiled with linseed oil to preserve it until it is ready to be dipped; no pipe to be dipped after the rust has set in.

The coal-tar pitch is to be made from coal tar, distilled until the naphtha is entirely removed and the material deodorized. It should be distilled until it has about the consistency of wax when cold. The mixture of five or six per cent. of linseed oil is recommended. Pitch which becomes hard and brittle when cold will not answer.

Pitch of the proper quality, having been prepared, must be carefully heated in a suitable vessel to a temperature of 300 degrees Fahrenheit, and be maintained at not less than this temperature during the time of dipping. The material will thicken and deteriorate after a number of pipes have been dipped; fresh pitch must, therefore, be added from time to time, and occasionally the vessel must be entirely emptied of its contents and refilled with fresh pitch; the refuse will be hard and brittle, like common pitch.

Every pipe must attain a temperature of 300 degrees Fahrenheit before it is removed from the bath. It may then be removed and laid upon skids to drip.

Pipes of twenty inches diameter and upwards will require to remain at least thirty minutes in the hot fluid to attain this temperature, probably more in cold weather.

* Engineer, Buffalo Water Works.

The application must be made to the satisfaction of the engineer, and the material and process be subject at all times to his examination, inspection, and approval.

I would not require the castings to be heated to 300 degrees before dipping, but would require them to obtain that temperature in the vat.

The hydrostatic test should be as you have it, and not for a general pressure of three hundred pounds for all pipes.

In general the specifications as you have reported are a great improvement and advance over what has been used in the past. As a whole I am in favor of them.

R. D. Wood & Co. * (by letter). With your esteemed favor of December 4 to Mr. Walter Wood, we received the copies of report of Committee of the New England Water Works Association on Standard Specifications, showing the suggested form for such specifications. We at once referred it to our foundrymen, and communicated with other pipe foundries. As yet we are unable to get satisfactory or complete reports as to how much the various changes would affect the expense and trouble of making pipe and specials. This extra cost would eventually, of course, be borne by the buyers, and would be a disadvantage to all foundries. There are some details which, for the mutual interests of water works and pipe makers, should be modified, — to what extent we cannot state until we can get an agreement with other foundries as to what would be a fair average of the several interests. Unfortunately, in the short time we have had the pamphlet, this has not been practicable, and we trust that no final action may be taken until we can meet your Committee with a full statement of our ideas on the several changes.

The Chairman. We have a representative of the United States Pipe Foundry here, Mr. Lemoine, and we would like to hear from him.

Mr. L. R. Lemoine. I do not know that there is very much that I can say on behalf of the manufacturers, because, as has been intimated in the letter just read, we have not had an opportunity of getting together. I can say on behalf of our own company, however, that a glance at these specifications indicates that there are a number of points in them which, from a manufacturer's standpoint, we think it would be to the interest of your Association to have carefully considered before they are incorporated in the final report. I have

* Pipe Founders, Philadelphia, Pa.

spoken to Mr. Brackett in regard to the matter to-day, and I will venture to refer to just one item. It is stated in one clause here that special castings must all be made in loam. That matter has been mentioned in one of the papers which has been read, — I think it was in Mr. McInnes'. Now, the general practice at most foundries, I think I am safe in saying, is that upwards of three fourths, if not four fifths of the special castings are made in green sand; and as the specials grow larger the practice in making them varies from green sand to a combination of dry sand and loam, and then loam. The practice also varies with the number of specials of a particular kind. For instance, take a 48-inch, $\frac{1}{16}$ bend; if only one is required for a certain dimension it may be cheaper to sweep it up. On the other hand, if there are fifty or sixty of them, it may be cheaper to make them in a combination of dry sand and loam, or entirely in dry sand, depending somewhat on the radius of the bend.

There are a great many items in the proposed specifications which I am sure the Committee will permit us at least to point out to them, which make it seem best, if the Association agrees with us, to have this matter referred back to the Committee, and ask them at their convenience to confer with the manufacturers — after giving the manufacturers a chance to confer among themselves; for I presume the Committee would like to have the manufacturers fully agreed before meeting them.

The Chairman. Before we have a discussion by any users of pipe, if there are any other representatives of pipe foundries here, we would like to hear from them.

Mr. Edmund F. Krewson. Mr. President and gentlemen, I represent R. D. Wood & Co. Mr. Lemoine has expressed our position quite fully. We are in hearty sympathy with this movement, and we realize the intelligence and care with which these specifications have been prepared; and yet we are unprepared to accept them until these matters, some of which Mr. Lemoine has indicated, are more thoroughly threshed out among the foundrymen. We have tried to get together, but we have been delayed. We think, however, in a short time we will be able to make such a presentation to your Committee as will be mutually satisfactory. We have no items to suggest now, being comparatively unprepared. I can therefore simply endorse Mr. Lemoine's position and say that we would like an extension of time.

Mr. Coffin. I believe Mr. Edwards, who represents the Montreal

Pipe and Foundry Company of Canada, is here, and I should like to hear from him.

MR. EDWARDS. I regret to say, Mr. President, that I have not the honor to be a member of the Association, but I have come here in response to the general invitation which is extended with the advance copy of the Committee's report. I might say that our views would be very much in line with those which have been expressed by previous speakers representing the manufacturers, namely, that there are many points here which ought to be handled with considerable care, and awaiting, possibly, the decision of the manufacturers.

If you will permit me, I will run over some of the matters mentioned in this printed draft of the report. In the first place, I would say, that the company which I represent probably differs from the larger companies in the United States, in that we make chiefly small pipe. We make mostly 6-inch, 8-inch, 10-inch, and 12-inch. While we have facilities for making the larger pipe, still 24-inch is the maximum size that we usually make. What I shall say, therefore, will have reference chiefly to small pipe.

The questions of joint room, and such matters, are ordinarily in the hands of the engineers, and they do not matter very much to the manufacturer, so far as I judge.

In connection with the percentage of accepted pipes which have cut ends, I notice it says that "no pipe shall be banded which is less than eleven feet in length, exclusive of the socket," and "not more than six per cent. of the total number of accepted pipes of each size shall be cut and banded." I presume that refers to pipes twenty inches or more in diameter, but by inference it would cover all classes of pipe. I should think, from the manufacturers' standpoint, that ten per cent. of cut ends would be a fair allowance, because fully that number are turned out from the average factory, and if only six per cent. were accepted it would throw a considerable percentage upon the manufacturers. I know the custom with us has been to include ten per cent., and in most cases that has been acceptable.

Then, as regards marking. The class letter is a point that is rather hard on the manufacturers, because in casting it is impossible to get the weights of pipe within the limits of the class provided in these specifications; and if a pipe were branded with a certain class letter, in case the weight limit was not reached or was exceeded, it would be branded in the wrong class, and would be rather bad stock

in the hands of the manufacturer. He would have to chip the class letter off and paint on a new one, which would rather detract from the value of the pipe. It seemed to me that the class letter could be very well left out, in the interest of the manufacturers.

And, also, the number signifying the order in point of time in which the pipe is cast is a point. While it is undoubtedly valuable to the engineer to know the running number of his pipes, still the pipe might be thrown back on the hands of the manufacturer through the clause which usually permits the engineer to decrease the contract by, say, twenty per cent.; and a pipe which was thrown back upon the hands of the manufacturer, bearing a certain number cast on it and also a class letter, would be dead stock, or stock for which there would certainly be but a limited demand.

Then, again, in small pipe, — and I am referring to small pipe especially, — the question of casting with hub end or bell end down, judging from the literature that is to be had in regard to the casting of pipes, is a matter on which there is a wide divergence of opinion at present; but these specifications would call for all pipes, no matter how small, to be cast with the bell end down. I know that the three factories which I represent have a large plant for casting with the bell end up, and to make a change would necessitate the incurring of considerable expense.

Special castings to be cast in loam is another feature, which a previous speaker has touched on. I know in our case green sand is used almost entirely for small castings.

On the question of hydrostatic test, it is provided in the specifications that all pipes in Classes E and F are to have, respectively, a pressure of 350 and 400 pounds per square inch. Now, applying that to the smaller sizes of pipes, the 4-inch and 6-inch, and even 8-inch pipe, even with the thickness provided for these respective classes, it is a very heavy pressure on pipe for purposes of testing in the foundry; and it seemed to me that a change to the effect that pipes, say under twenty inches, need not be tested to a higher figure than 300 pounds would cover the ground very well. According to this, a 4-inch pipe in Class G only runs twenty pounds to the foot, which is a fair average weight from previous practice, and that would be subject to a test of 400 pounds to the square inch.

That brings up the question of the weights of pipe as provided here, Class A, 4-inch, being down as low as 200 pounds, and the very heaviest class only being 240 pounds. I think the experience of pipe

manufacturers has been that those figures have been very radically exceeded in average work, running from 230 as a minimum, perhaps, to 260 or 270 as a maximum, instead of from 200 to 240.

I just mention these points, Mr. President, as briefly indicating our views on the matter.

THE CHAIRMAN. It has always seemed to me that if there was any difference in the quality of the iron the best iron should be in the bell end rather than to have it in the spigot end.

MR. DEXTER BRACKETT. In explanation of some remarks made by Mr. Edwards, I wish to state, with regard to defective spigots, that this clause in the specifications is intended to provide that the spigot ends on pipes smaller than twenty inches shall not be cut off under any condition. This rule I have followed in my practice, and I think it has been followed by many other engineers, and I might say that the foundrymen do not seem to have any difficulty in making pipes of which a very small percentage are rejected for that cause. The reason for allowing a small percentage of the larger sizes to be cut and banded is that the loss of a large pipe is of more importance than of the smaller sizes.

In regard to the casting of the special castings in loam, I must say that the insertion of that clause in its present form was a mistake, as I knew that special castings, of the smaller sizes, are not made in loam, and although the specifications state that they may be made in other ways by special permission, it would hardly be desirable to require special permission for every order for small castings.

With regard to the suggestion that the hydrostatic test required is excessive for smaller sizes of pipe, I would say that if any criticism were to be made it should be made in directly the opposite direction. For the smaller sizes of pipe, the formula used provides an addition of .25 of an inch in thickness for deterioration by corrosion. For this reason, the thickness of the smaller sizes is double that needed to withstand the pressure for which the pipes are designed, while for pipes of large diameter the addition of .25 of an inch is a much smaller proportion of the total thickness, and there is more risk of getting an excessive pressure in testing the large sizes than there is in testing the small ones. I think that any of the smaller sizes of pipe will probably withstand, when new, a pressure of one thousand pounds per square inch.

MR. W. H. RICHARDS.* It is with much hesitation that I offer any

*Superintendent of Water Works, New London, Conn.

criticism of the specifications for cast-iron pipe as presented by the Committee, knowing the difficulties under which the Committee labors in an endeavor to reconcile the many divergent ideas on the subject; but as suggestions are invited, I offer the following: —

(1) That the specification contain a specific declaration that no cut pipe under twenty inches in diameter will be accepted.

(2) That the hydrostatic testing pressure be reduced as the size of pipe increases, thus giving a more nearly uniform strain on the iron. As specified, the actual strain on a 24-inch Class D pipe is double that on a 6-inch Class D pipe, which is inconsistent.

(3) That further consideration be given by the Committee to the depth of bells. Examples are not wanting in nearby cities of bells on 10-inch and 12-inch pipe less than three inches deep, and after years of use. As the saving in weight of one inch depth on the bell is nearly equivalent to all the saving between two classes of pipe, there ought to be a good reason given for adhering to an antiquated design.

Mr. Brackett. The thickness in the small pipes is not required to withstand the internal pressure, but the strain due to settlement. In fact, I think in Boston they now use fully as heavy pipes for gas as they do for water.

Mr. Robert J. Thomas. I would like to hear from Mr. Macksey, of the Boston Water Works.

Mr. H. V. Macksey. I have very little to add to the discussion at this time. Mr. Edwards seemed to think that the branding of the classification would cause some difficulty for the manufacturers. I cannot see that any great expense would be caused thereby. My experience has been that manufacturers have always kept very well within the weights specified, the pipe running too heavy rather than too light as a rule; but if a manufacturer feared that he could not keep within his limits and would have a wrong letter branded on a pipe, I see no reason why he could n't brand all the letters in series on a pipe and then take the one which fits the pipe as cast. For instance, he could have three class brands and then cut off the two which do not fit. There would be very little labor lost. So, also, in regard to putting on any special water-works brand which may be desired, and the numbering of the pipe. It seems to me very important that there should be a method of identifying pipe, because experience has shown that quite a number of pipes which have been condemned at the factories reach the works. It is a very

easy matter for the manufacturer to cut off any brand, provided the pipe is rejected at the foundry. It has been my practice to request that that be done immediately, and the manufacturers have always complied, with the exception of one who made it a practice to break up all small pipe which were refused by inspectors, never putting any into stock. So really I cannot see that these little things would make any practical difference to the manufacturers, and I think they are very important to water departments. I quite agree with the Chairman that the place to have good iron is in the socket, and I think that the specification as to the position in which the pipes should be cast is quite important.

THE CHAIRMAN. I will call upon Mr. Gould, engineer of the Gas Companies.

MR. J. A. GOULD.* I do not know that I have anything of importance to add, only, as the subject of gas pipes has been mentioned, I will say that the gas pipes used in the city of Boston are as heavy as the high-service pipes which are used by the Boston Water Department. A 12-foot length of 8-inch gas pipe weighs six hundred pounds, the same as pipes used for the high-pressure service, while the gas pressure is about two ounces to the square inch.

THE CHAIRMAN. Do you have any breaks?

MR. GOULD. We do.

I do not think I have any real criticism to make upon the report of this Committee, but will mention one thought that has occurred to me; that is, whether it is necessary to have so many different classes of pipe, varying for each fifty feet of head, or for each twenty-two pounds of pressure.

A pipe that is thick enough to take a good thread for the service tap is strong enough to stand the water pressure of most water works. For instance, a 6-inch pipe that is three-eighths inches in thickness can be tapped satisfactorily for water or gas services; and this is practically the thickness of a light-weight gas pipe. This pipe, if made of iron of the standard tensile strength of sixteen thousand pounds to the square inch, should not break until it is subjected to a water pressure of two thousand pounds to the square inch.

The danger to most pipes is not from the pressure in the pipes, but from the strains due to the settlement of the material in which

* Chief Engineer, Brookline and Dorchester Gas Light Companies.

the pipe is laid. For this reason it has been the custom of the local gas companies to order two classes of pipes; one which corresponds closely to the Class B of this report, or suitable for one hundred feet of water, is laid in the suburban districts, and another class, which has practically the same weight as the high-service pipe of the Boston Water Department, is laid in city streets where the pipe is liable to be undermined by other parties, especially the Sewer Department.

In this connection a list of the weights of gas mains laid in Boston and vicinity may be of interest.

Diameter, Inches.	*Suburban weights, Pounds per 12-ft. length.*	*City weights, Pounds per 12-ft. length.*
4	230	260
6	350	400
8	500	600
10	675	800
12	850	1 000
16	1 300	1 485
20	1 850	2 100
24	2 400	2 700
30	3 600	4 000
36	5 200	5 200
42	6 200	6 200

By comparison with the tables of weights in report of the Committee, I think few water-works engineers would hesitate to trust the pressure from their works in pipes of above weights, while the gas engineers with no internal pressure in their pipes demand these heavy pipes for other reasons.

MR. FRANK L. FULLER.* I think this Committee has done a good thing in recommending a scheme by which foundries can make pipe to keep in stock. We all know how troublesome it sometimes is, when we are in a hurry to get an order of pipe, to have to wait for it to be cast, because we cannot get just what we want. Now it seems to me that this will obviate that trouble to a large extent, and I think there will be less pipe laid which is unnecessarily heavy. I remember that the first pipe which was laid in the town of Marblehead was a 10-inch line, bringing water from a little pond to supply several hydrants. I do not suppose the head was more

* Civil Engineer, Boston, Mass.

than fifty feet, but that 10-inch pipe weighed eighty pounds to the foot, which, of course, was vastly heavier than there was any necessity for.

On page 92 it is specified that "No pipe shall be accepted when the thickness of metal in the body of the pipe is more than .08 of an inch less at any point than the standard thickness given in table No. 2." It seems to me that would be a little difficult to carry out, although, of course, it is a good thing. We often test pipe by rolling it to find whether it is of uneven thickness; but it would be rather difficult to caliper pipe at the center and find out just what the thickness is.

Under the head of "Special Castings," near the bottom of the same page, it reads that they "shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications"; and it says elsewhere, or has been stated by the Committee, that the weight of specials should be determined in advance. I do not see, unless the length of the branches is given, how the weight of the specials can be determined.

With reference to how the pipe shall be cast, it seems to me that perhaps on the whole it would be better to have it cast bell down and get a good bell. But, on the other hand, we often get a good many poor spigots, and in my experience I have had very few cracked bells. There have been a great many more cracked spigots than cracked bells. If they were cast bell end up, I should expect better spigots.

Referring to testing pipes, the specification says, "They shall also be subjected to the same proof by water pressure and hammer test after their delivery and before their final acceptance, if required by the engineer." It does not say at whose expense. I suppose that is after they are delivered to the town or city where they are to be used, but it seems to me something should be put in to make that a little more definite.

It says that castings shall be "delivered sound and perfect," and it there refers to the way in which they shall be cast. There is one trouble in connection with the receipt of pipes when they are not inspected at the foundry. They may be all right when they leave the foundry, but when they are put upon the railroad there comes in the question of a divided responsibility; and in my experience I have found that by the time the pipes were laid along the trench there were often many cracked spigots. The makers would insist that the

pipes were all right when they left the foundry, and say that the cracking took place on the railroad cars; and I presume this may be to a large extent true. In switching and shifting, the cars are often thrown violently together. As there are generally two tiers of pipe upon a car, the spigots come in contact with the pipe opposite, and very likely a good many spigots are cracked in this way. And then, again, I have seen a good many pipes that were badly cut into by the fin on the bead of the adjoining pipe. The fin would be very hard, sharp, and thin, and it would cut not only through the coating, but into the pipe itself. Of course, being on the outside, it would not do the damage that it would if it were on the inside, but at that particular point it cuts through the coating and allows corrosion to begin.

It seems to me that the dimensions of the depth of socket and the joint room agree very well with average practice, and I think that the Committee has done good work and deserves our thanks for putting this matter in such shape as it is now in; and I believe that with the changes that are likely to be made we shall have made good advance in pipe specifications.

MR. E. H. GOWING.* I should like to say a few words about this matter of thickness of pipe, in reply to the suggestion made that it is perhaps unnecessary to have more than one size, and have that heavy enough for everything. That might be very well in places where people have lots of money; but some of us are poor, and cannot afford it. The 8-inch pipe which the gentleman said weighs six hundred pounds to a length will, at the present prices, cost ten cents a foot more than another class of 8-inch pipe which it would be quite proper to use in a great many places. That means five hundred and twenty-eight dollars a mile, or for a ten-mile system in a small country town it would mean over five thousand dollars. In many places five thousand dollars means much more than it does to the large gas companies or the water departments of large cities; so that if lighter weights can be used in these small places, I believe they should have a chance to get them. I think practice has abundantly proved that the lighter weights are practicable under many conditions, and so I want to support the Committee heartily in their plan of different classes for different situations. Pipe laid in a city street, particularly gas pipe laid near the surface, is subjected to strains which water pipe laid in a 6-foot trench in a country town

* Civil Engineer, Boston, Mass.

never meets. It seems to me that the man who orders the pipe should have sense enough to order a heavy weight pipe for a city street, and a lighter pipe for a country road where there will be no strains due to settlement, where there will be no teaming to affect it, and where it can remain in its position for years without ever being subject to outside strains of any kind. I have some other things which I may want to speak of later, for certainly this discussion will have to go over to another day, and I will say no more now.

(*January 8, 1902; discussion continued from December meeting.*)

MR. COFFIN. I believe the Committee has nothing new to offer to-day, Mr. President. Since the last meeting a few written discussions have been received, but the Committee has taken no further action, and we are waiting for further discussion before we submit our final report.

MR. BRACKETT. As Mr. Coffin has stated, we have received a number of discussions, and possibly if they are read it may bring out further discussion here. I may say that we have received letters during the past month from the pipe manufacturers, stating that they have not yet been able to get together for a conference, but a meeting has been appointed to be held on the 16th of this month. After that meeting we expect to have a conference with a committee representing the pipe founders, and then may be able to report the specifications in somewhat more final form.

MR. LEONARD METCALF.* After the excellent report of our Committee I hesitate somewhat, Mr. President, to appear to criticise it, but there are certain points in the specifications on which I had hoped there might be some discussion. Perhaps I have viewed the specifications from a little different standpoint from that of many members, that is, from the standpoint of the small purchaser, who wishes to be safeguarded in the quality of the pipe which he buys in the open market, just as is the large city which has its engineers, and which has an inspector at the foundry: and in that connection I had certain suggestions I wanted to bring forward as to changes in the specifications.

First of all, there are two or three paragraphs in the specifications as printed where the matter of tests is left to the discretion of the engineer. If I remember rightly, the hydrostatic test is the only

*Civil Engineer, Boston, Mass.

one which is definitely required of the foundry. The hammer test, in conjunction with the hydrostatic test, is left to the judgment of the engineer, as is also the making of tests of the properties of the cast iron by means of little beams, — transverse tests. Now, it has seemed to me that if it is worth the while of the large cities, which are purchasing large amounts of pipe, to have these tests made, it should be equally worth the while of the small consumer to know that he is getting pipe of the grade called for in these specifications, an equally good pipe, in short; and the only way in which he can do that is to have tests made in a similar manner.

In many cases, — perhaps in most cases, — it would be out of the question — according to his way of thinking, at any rate — for him to employ an engineer and to have a pipe inspector upon the ground; and it seems to me that the specifications should be drawn in such a way that if he calls for pipe under these specifications he will get the same kind of pipe that the larger cities, buying pipe under these specifications, would get through their engineers.

Taking up these points one after the other, briefly; — I will refer first to the paragraph under "Quality of Iron," the beginning of the second paragraph: "Specimen bars of the metal used, each being twenty-six inches long by two inches wide and one inch thick, shall be made without charge as often as the engineer may direct" (*i. e.*, left optional with the engineer). In other words, if there is no engineer, the foundry will not make such specimens and will not test them. I would therefore suggest that in that paragraph such a sentence as this might be embodied: "In default of definite instructions the contractor shall make and test at least one specimen bar from each heat or run of metal."

Taking up the hydrostatic test as the next point, making the hammer test in conjunction with the hydrostatic test, I would strike out the clause, "If required by the engineer," and make it read that the pipe shall be tested by hydrostatic pressure, — "And they shall also be subjected to a hammer test under this pressure." With the inspector on the ground, of course, that may be dispensed with, so that the engineer of the large consumer may use his own judgment; but under other circumstances the test would be made.

The third point is in regard to the method of quoting prices upon the pipe and making settlement for it, — whether we should use the long or the short ton. It seems to me it would be desirable to have that appear in the specifications as a mere matter of convention and

convenience; and to this end I would suggest in the paragraph under "Weighing," that some such clause as this might be inserted: "Bids shall be submitted and final settlement made upon the basis of a ton of two thousand pounds."

Finally, under the heading "Contractor to Furnish Men and Materials," I would change the last half of the paragraph so as to read, "And if the pipe is not inspected at the works by the engineer, the contractor shall furnish a sworn statement that all of the tests have been made and the requirements fulfilled, and if the pipe is specially cast to fill a given order the specific results of the tests shall also be submitted." This would do away with the complaint that the manufacturer might make that he could not keep track of the individual pipe that he puts into stock and of the tests which he made of the material which went into this pipe. Where the pipe is taken from stock, the consumer would merely know that all of the pipe which is in stock had passed the tests, but the large buyer, for whom the order is specially cast, would, of course, have the specific tests covering that pipe.

Referring to the hydrostatic tests which are required, it seems to me that the pressures which are stated here are small, particularly for the lighter weight pipe. Certainly, in many of the smaller water works which have been built in this country, very much lighter weights have been used than — or, let me put it in this way, — as light weights as Class A pipe of this table have been used for pressures of 100 to 125 pounds, under specifications requiring a hydrostatic test of 300 pounds per square inch. I have taken the figures which are given in these tables for the thickness of pipe, and figuring backward, making use of the factor of safety of 5, which is suggested, have figured out the pressures which the pipe should stand. Upon that basis it would be entirely safe to use very much higher hydrostatic pressures than are called for under this test. Indeed, it might well be as high as 300 pounds for pipe of all classes up to 10 or 12 inches. That is, I find, for instance, in Class A, that on the 4-inch the strength is five times 561 pounds; the 6-inch, five times 418; the 8-inch, five times 346; the 10-inch, five times 310; the 12-inch, five times 270 pounds, and so on. So it seems to me that the hydrostatic pressure might well be increased considerably beyond the limits suggested in this report.*

That brings up the question as to the number of classes of pipe

* See Table B, page 123.

— Diagram —
SHOWING THE
Variation in Weights
— AND THE —
Overlapping of Individual Classes of Pipes
UNDER THE CLASSIFICATION SUGGESTED BY
The New England Water Works Association
Committee on Standard Specifications for Cast Iron Pipe
DECEMBER 11, 1901
LEONARD · METCALF MARCH, 1902

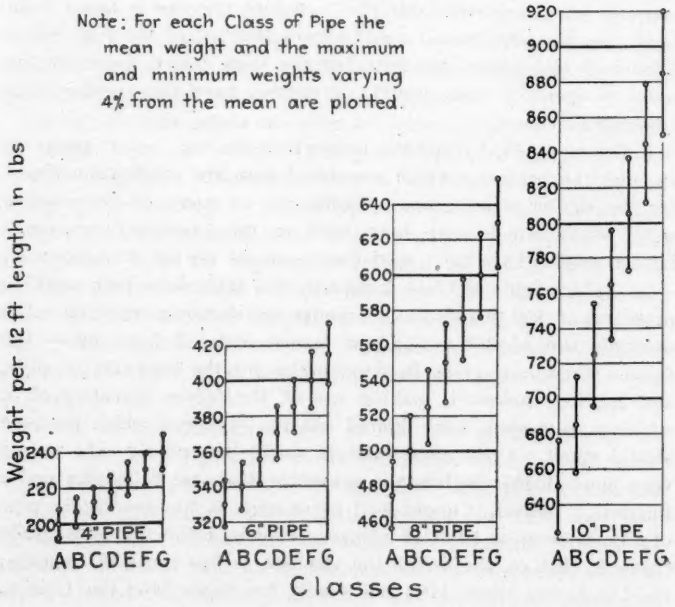
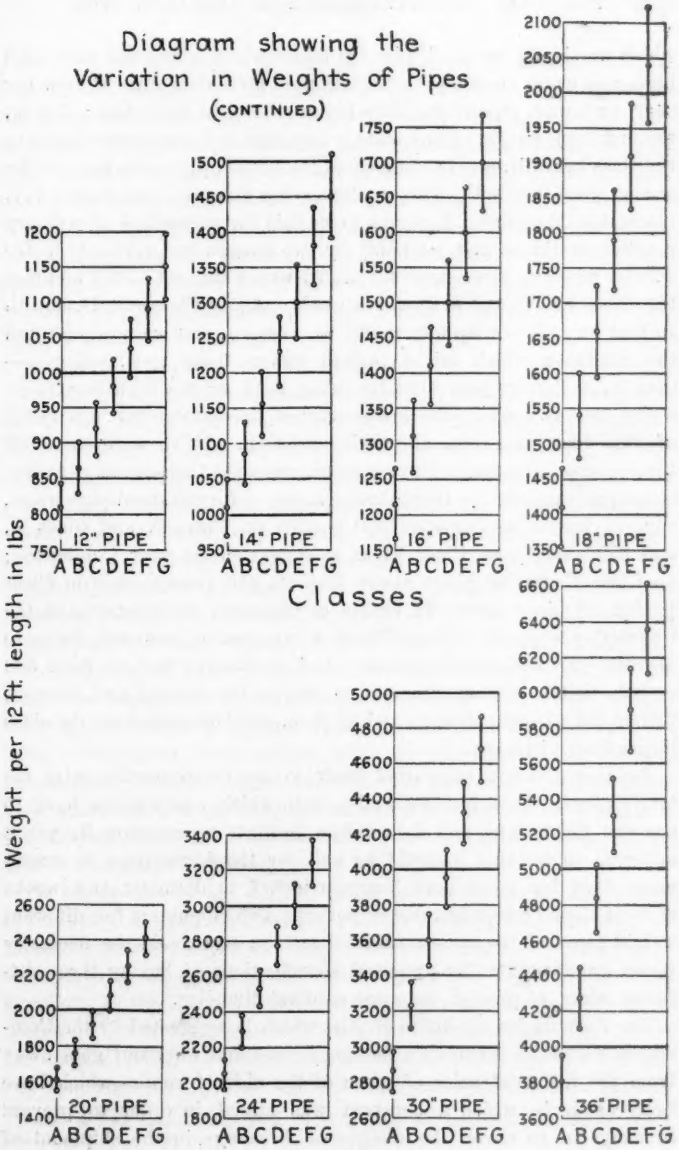


Diagram showing the Variation in Weights of Pipes (CONTINUED)



which we should have. Under the tables which have been submitted here, and using an allowable variation on individual pipe of four per cent. each way, pipe of one class lap over into the next class; that is, the minimum weight of one class is less than the maximum weight of the class below it, and in some cases the smaller pipe even lap into the second class beyond. The accompanying diagram, pages 116, 117, illustrates this point. It seems to me that the necessities of ordinary practice would be met, probably by two classes but certainly in the smaller pipes by three classes. And I would suggest to that end that the Classes A, C, and F should be used, omitting Classes B, D, and E. In that way all overlapping would be avoided, and we would n't find the condition which might prevail under these specifications, — that is, a lighter pipe actually being used on the high service of a city than is used in the low service of the same city, as a result of this four per cent. allowable variation. If we were to adopt three classes, instead of five classes, we could then use as a hydrostatic pressure test for those three classes, — for the small pipe up to, say, 12 inches in diameter, 300 pounds on Class A and Class C, and 350 pounds on Class F, as is suggested by your Committee; on Class C, for all pipes above 12-inch, 250 pounds, and on Class F, for all pipes above 12 inches in diameter, 350 pounds, as the Committee suggest. Upon Class A we would, however, have to decrease the hydrostatic pressure test gradually; that is, from 300 pounds on the 12-inch diameter to 250 on the 14-inch and 16-inch, 220 on the 18-inch, 20-inch, and 24-inch, and 150 pounds on the sizes larger than 24 inches.

Another thought suggested itself to me in connection with the larger pipes. It is not a question with which many works have to concern themselves, and I therefore hesitate to mention it, yet it occurred to me that it would be well for the Association to recommend that for pipes over fourteen inches in diameter new works at least should adopt but one or perhaps two diameters for different weight pipes of the same nominal diameter, and avoid the necessity which exists under the proposed specifications of having three different sizes of pipe of the same nominal diameter.

The formula for thickness of pipe which is suggested by the Committee seems to me to be a thoroughly rational one, and gets away from the inconsistencies of some of the older formulæ which have been used, in which a constant was added in order to prevent breakage or to cover the danger of breakage in the shipment of

pipe. In this connection it may be of interest to mention a paper that Mr. N. Henry Crafts published, in the form of a report to the town of Watertown, in 1876, which, apparently, has had considerable influence in determining the weights of the smaller sizes of pipe that have been used in many of the small works that I speak of. I have with me a list of the weights which have been used by Mr. William Wheeler in his practice in some fifteen or twenty works, which are very much like the lighter weights that Mr. Coffin spoke of at one of the meetings during 1900,* and which I should be very glad to summarize for publication in the JOURNAL if you think it would be of interest.

This is all I have to say, Mr. President.

MR. COFFIN. I did not expect to take any part in this discussion to-day, but Mr. Metcalf has raised several interesting points, about some of which I quite agree with him, and I would like to say something about them just at this time. The Committee have had a good many very valuable suggestions presented to them, and will consider all of them; but I would ask the members to remember that there are several points of view in this matter, and the Committee, whatever the personal preferences or ideas of its individual members may be, has to consider them all. What would suit one person would not suit another, and it has been the endeavor of the Committee right along to get a specification which might, on the whole, be acceptable to everybody. In saying this, speaking just after Mr. Metcalf has spoken, I do not mean to be understood as being antagonistic to any of the points he has suggested in the way of changes. The Committee will consider them, but still it may be that, while some of the suggestions are very valuable, — looking at the subject from one point of view, — the Committee may not be able to recommend the adoption of any of them.

He has spoken of the weights in the different classes, and I want to refer to that now, while we are all here, hoping that there may be further discussion upon it. The matter has been very thoroughly considered in Committee, and while some of us would prefer more simplicity in the classes, still it seems to me that if we are going to prepare a list of weights which would be acceptable as a general list for specifications, we must have more than three classes; not that any one man may use as many classes as another, but that any

* See "A Few Notes on Cast-Iron Pipe," Journal New England Water Works Association, September, 1900, Vol. XV, p. 38.

engineer in buying pipe may be able out of those classes to select a list which will suit his practice. For instance, I could pick out of that list three classes which would cover everything I should care to use. Another engineer might also pick out three classes, but would, perhaps, want different classes from mine. He might want heavier pipes for certain cases than I would, or he might want lighter pipe. That was the idea of having all these classes.

It is very easy to see that it would be better, if possible, to have fewer classes, more especially, I think, on account of lettering the pipe. If the founder has to letter the pipe, he does n't know when he casts his first pipe in any lot just where he is going to strike; it is a matter of experiment, as I understand it. He may cast pipe intended for Class B and they may run over Class B into Class C, or possibly run under into Class A; and if the letter is cast on it, of course that fixes the class and he must lose the margin, or it must be arranged in some other way. That, I should imagine, would be one of the criticisms that the founders will make, and it is, as far as I can see, the worst objection to our classification. I therefore wanted to explain why the weights were classified in this way.

I was very glad to hear Mr. Metcalf speak of his practice in using different weights of pipes. I suppose you have noticed in reading the report that the Committee had tried not to commit the Association to the endorsement of any particular weight of pipe for special work or special conditions. The Committee has explained how the classes have been computed, but in the specifications themselves there is nothing to commit the Association to any weight for any pressure in any class. I think it is very desirable to have some discussion on that point, and I, for one, would be very glad if Mr. Metcalf would tabulate his weights and have them go into this discussion.

Mr. Brackett. I would like to ask Mr. Metcalf whether he would build a reservoir or a filter gallery or a system of sewerage without inspection, and take the sworn statement of the contractor that the work had been carried out in accordance with the specifications. That, I understand, is what he proposes to do in the case of cast-iron pipe. I do not think you can be sure of getting good work unless you employ an inspector to see that it is done in accordance with the specifications. Some of the points which Mr. Metcalf has mentioned were intended to be covered by the specifications, and I think he will find that they are. I may say that in general I agree with his suggestions.

MR. METCALF (by letter, March 27, 1902). In further comment upon the subject of the weight of cast-iron pipe, I send herewith a table of weights of cast-iron pipe according to different authorities (Table A, page 122).

Without attempting to state specifically all of the weights of pipe used by Mr. William Wheeler upon different water works constructed by him, I have tabulated under the head of "General" and "Heavy" the two classes of weights ordinarily used by him, — the first for service in small communities; the second in cities where considerations of heavier street traffic, greater liability to future disturbance by excavations in the street, and heavier pressures for high service, govern.

The class "General" has been used even under such high pressures as those prevailing at Winchester, Ky., a city of about six thousand inhabitants, in which the pressures have the following range: —

On the 12-inch pipe, from 30 to 60 pounds per square inch.
On the 10-inch and 4-inch pipe, from 45 to 125 pounds per square inch.
On the 8-inch and 6-inch pipe, from 50 to 75 pounds per square inch.

The class "Heavy" was used, for instance, at Knoxville and North Knoxville, Tenn. (and other cities), where a population of about forty-five thousand or fifty thousand is supplied, and where the pressures range from thirty to one hundred and twenty-five pounds.

The weights used by Mr. Freeman C. Coffin are quoted from the JOURNAL of New England Water Works Association for September, 1900, with the exception of those contained in the last column, marked "Lightest," which were kindly given to the writer by Mr. Coffin.

The weights suggested by Mr. N. Henry Crafts were taken from his report to the town of Watertown, Mass., dated July, 1876.

It seems hardly necessary to reply to the question of Mr. Brackett, as to whether the writer "would build a reservoir, or a filter gallery, or a system of sewerage, without inspection, and take the sworn statement of the contractor that the work had been carried out in accordance with the specifications." He would certainly not to do so, and as Mr. Brackett doubtless knows, he is a thorough believer in the careful inspection of all materials of construction, as well as the actual execution of the work.

Yet the fact should not be overlooked, as previously stated by the

TABLE A. — WEIGHTS OF CAST-IRON PIPE ACCORDING TO DIFFERENT AUTHORITIES.

COMPILED BY LEONARD METCALF, MARCH, 1902.

Diam. of Pipe.	WILLIAM WHEELER.				FREEMAN C. COFFIN.*								N. HENRY CRAFTS.				N. E. W. W. A. COMMITTEE, 1902.					
	GENERAL.		HEAVY.		LIGHT.		STANDARD.		HEAVY.		LIGHTEST.		LIGHT - 65 lbs. PRESSURE.		HEAVY-150 lbs. PRESSURE.		CLASS A.		CLASS C.		CLASS F.	
Inches.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.	Per Ft.	Per 12′ Length.
3	14	168	14	168	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	17	204	18	216	17	204	19	228	22	264	16.4	197	18	216	18	216	16.7	200	17.7	212	19.2	230
6	28	336	29	348	27	324	30	360	35	420	26.3	315	28	336	28	336	27.6	330	29.6	355	33.3	400
8	40	480	42	504	40	480	45	540	50	600	36.7	440	39	468	44	528	39.6	475	43.8	525	50.0	600
10	53	636	57	684	54	684	60	720	70	840	50.0	600	52	624	65	780	54.3	650	60.4	725	70.4	845
12	67	804	74	888	68	816	80	960	90	1 080	64.1	768	65	780	87	1 044	67.5	810	76.7	920	90.9	1 090
14	..	1 116	93	1 116	85	1 020	100	1 200	115	1 380	79.4	952	80	960	113	1 356	84.3	1 010	96.5	1 155	115.0	1 380
16	..	1 368	114	1 368	105	1 260	125	1 500	145	1 740	101.2	1 215	96	1 152	143	1 716	101.2	1 215	117.5	1 410	141.6	1 700
18	..	..	137	1 644	120	1 440	150	1 800	175	2 100	114.2	1 370	..	..	..	..	117.5	1 410	138.3	1 660	170.0	2 040
20	..	.	162	1 944	140	1 680	175	2 100	205	2 460	133.6	1 603	134	1 608	213	2 556	134.2	1 610	160.0	1 920	200.8	2 410
24	..	..	..	..	185	2 220	225	2 700	270	3 240	..	..	175	2 100	298	3 576	170.8	2 050	210.8	2 530	270.0	3 240

* See JOURNAL New England Water Works Association, September, 1900. "Light," safe for 100 feet head; "Standard," safe for 350 feet head; "Heavy," for city use and higher heads than 350 feet.

writer, that with much of the pipe that is laid there is no inspection of the pipe prior to its superficial examination on the ground where it is to be used.

Hence the writer is of the opinion that the Association should do all in its power to maintain and improve the standard of the product turned out at the pipe foundries in the interest of the small consumer as well as of the large.

The following tables, bearing upon the hydrostatic testing of cast-iron pipe, are appended in amplification of the writer's remarks upon this subject.

TABLE B.

COMPUTED* BY LEONARD METCALF, FEBRUARY, 1902.

Diameter, Inches.	CLASS A.		CLASS C.		CLASS F.	
	Thickness, Inches.	Allowable Static Pressure, Lbs. per Sq. Inch.	Thickness, Inches.	Allowable Static Pressure, Lbs. per Sq. Inch.	Thickness, Inches.	Allowable Static Pressure, Lbs. per Sq. Inch.
4	0.34	561	0.36	594	0.40	660
6	0.38	418	0.42	462	0.48	528
8	0.42	346	0.48	396	0.56	462
10	0.47	310	0.53	350	0.63	416
12	0.49	270	0.57	313	0.69	379
14	0.53	250	0.61	288	0.75	354
16	0.55	226	0.65	268	0.80	330
18	0.57	209	0.69	253	0.86	316
20	0.60	198	0.72	238	0.92	304
24	0.64	176	0.80	220	1.03	284
36	0.79	145	1.02	187	1.37	251
48	0.95	131	1.25	172	1.70	234
60	1.10	121	1.50	165	2.10	231

*By slide rule.

HYDROSTATIC TESTS SUGGESTED BY L. METCALF.

DIAMETER OF PIPE.	PRESSURE (POUNDS PER SQUARE INCH).		
	Class A.	Class C.	Class F.
3 in. to 12 in., inclusive	300	300	350
14 in. and 16 in.	250	250	350
18 in., 20 in., and 24 in.	200	250	350
30 in. and over	150	250	350

MR. JAMES H. HARLOW* (by letter). I am in receipt of an advance copy of the report of the Committee on Standard Specifications for Cast-Iron Water Pipe.

In looking over the report somewhat hastily, I have been struck with the weights recommended by the Committee in Table No. 2. In this connection I would follow the Committee where the Committee says, "Believing that to the engineer or superintendent should be left the final decision as to the thickness of weight of pipe suitable for the particular place in which it is to be used."

I note the Committee recommends an allowance for water hammer of one hundred and twenty pounds in the small and about seventy pounds in the larger sizes. From my experience on the pipe lines of the Pennsylvania Water Company, it seems to me this water-hammer allowance is far in excess of the necessities of the case. The Pennsylvania Water Company's pipe lines are subject to a static pressure of about one hundred and fifty pounds per square inch. This, during the day-time period of greatest demand, is reduced to about one hundred and thirty-five pounds. As will be seen by the daily record enclosed,† we have no hammer in our lines, and in the experience of twelve years since this work has been constructed, I do not recollect of a water hammer that would exceed ten pounds, as shown by the recording gauge.

Again, it seems to me that the .25 of an inch to be added to the calculated thickness of pipe is hardly necessary.

With the exception of 4-inch pipe, the weights given under Table No. 2, Class C, are about the weights used by us, in the place of Class G, shown in the table.

The Pennsylvania Water Company has a mileage exceeding one hundred miles of pipe, varying in size from six inches to forty-two inches.

If pipes of Class G had been used, the interest on the excess cost would have been between four thousand and five thousand dollars per year, while the cost of making repairs to breaks in pipes, other than those caused by sinking of sewers, etc., has been less than one per cent. of this sum.

I believe, from our experience, that the weights of the pipes as given by the Committee can be very materially reduced.

We find that $t = \frac{hd}{13\,500}$ to be safe, in which t = thickness of pipe in inches, h = head in feet, and d = diameter in inches.

* Civil Engineer, Pittsburg, Pa. † Not reproduced. — EDITOR.

I am pleased to see that the Committee recommends that the outside dimensions of the pipe are to be standardized, making the variations for the several thicknesses on the inside of the pipe, as this will enable special castings to be standardized also.

MR. BRACKETT. If no one else desires to say anything at this time you may be interested to hear some of the written discussions which we have received. To show the interest which is taken in this question, not only here but abroad, I will read the following from the British Association of Water-Works Engineers: —

LONDON, December 17, 1901.

DEXTER BRACKETT, Esq.,
Boston, Mass., U. S. A.

Dear Sir, — I am much obliged for your letter enclosing a copy of the report of your Committee on Standard Specifications for Cast-Iron Pipe, which was submitted to the New England Water Works Association on the 11th inst. I much regret that this was not forthcoming for the consideration of our Association at their meeting on the 7th inst., more particularly as in the course of the discussion on that occasion the question of standardizing cast-iron pipe dimensions, etc., was strongly urged by many of the speakers, and was, in fact, referred to our Council for further consideration. . . . I should like to ask you, as one of the Committee, whether there would be any objection to our publishing this report, and also whether you could let me have, at an early date, a record of the discussion which took place at your meeting.

I am sure my Council will highly appreciate the opportunity of enabling the water-works engineers in this country to coöperate with their brother engineers in America both in connection with this subject and any other of the many problems which from time to time call for solution at their hands.

Thanking you on their behalf for your interest in our proceedings, which I am sure will be heartily reciprocated, I remain,

Yours faithfully,

PERCY GRIFFITH, *Secretary,*
The British Association of Water-Works Engineers.

MR. BRACKETT. I have a discussion from George E. Manning, of New London. I am not acquainted with the gentleman, but I judge from what he has written that he is familiar with the manufacture of pipe.

MR. GEORGE E. MANNING * (by letter). The feature of the design which provides that the outside diameter for each size shall be uni-

* Civil Engineer, New London, Conn.

form and all changes of thickness made by changing the inside diameter is to be commended, not only from the pipe-layer's point of view, but because the manufacturer can consider it a concession to his interests. Changes of the inside diameter can be easily made in a few minutes; but to change the outside diameter requires the casting of an iron pattern and the turning of it down in a lathe to the proper size, and if three pipes are cast in one flask, as is the practice for small sizes in some foundries, three patterns must be made.

A foundry cannot give a low price and go to this expense for a small order.

The extra patterns, which the other method requires the maker to provide, deteriorate from rust when not in use almost as fast as by use.

There are three methods of making the molds for cast-iron water pipe.

1. *Dry-sand molds*, used for straight pipe.

2. *Loam molds*, used for large special castings. In this case a rough form is built out of bricks. This is covered over and brought to the exact shape desired with a clayey material, which, when baked, is a low grade of brick itself. A loam mold is expensive to make, but is quite sure to give a good sound casting.

3. *Green-sand molds* are used for all small special castings. This is the process in use in all iron foundries. The Association should not adopt a standard specification that required the maker to obtain, in writing, permission to use green-sand molds for small specials.

There has been a great deal said as to which end of the straight pipe should be cast down. An examination of the scrap heap at a pipe foundry will show that this is one of the most important items of the specifications. The carbon, silicon, etc., which are constituents of all cast iron, are of less specific gravity than the iron itself. When the cast iron is in a fluid state these lighter parts are constantly rising toward the surface. When the spigot is cast up, the runners cover the upper surface of the end of the pipe so well that the lighter matter readily rises into the casting head, leaving the pipe itself in good condition.

With the hub end cast up, the runners cover but a small part of the end of the hub, and the bottom of the socket also provides a lodging-place for the cinder. The hub of a pipe cast with that end up will, in almost every case, show, when broken, holes and

collections of cinder. When subjected to the proof of three hundred pounds to the square inch hydrostatic pressure, leaks will frequently show at once, but in many cases the water will begin to come through only after the pipe has been under the pressure two or three minutes. Upon examination it is often found that the passage for the water is several inches long from the point of entrance to the outlet.

All makers cast large pipe with hub end down, and some cast all sizes that way. A pipe maker who has the facilities for doing the work both ways will, if he has had experience with inspectors, usually prefer to make the pipe hub down for rigid inspection; for he knows there will then be fewer rejections.

The hydrostatic test, or proof of the pipe, is a most important item of the specifications. Where a good inspector is not standing by, however, it is often little more than a farce. More pipes are cast at some foundries than can be put through the proving press, if sufficient time is given to each one. The standard specification of this Association should provide that the pressure be held for at least one minute.

Providence and other cities where Mr. Shedd has been the engineer employed are using pipes with a depth of bell much less than that given in the table. If a depth of two and a half inches gives good joints, why buy iron to make a depth of three inches? No more lead is used for the deeper joint, I am told, but the difference is in the amount of yarning used. This, I am told by men who have calked both kinds of joints, tells against the deeper joint. It is more difficult to compact the lead against the larger quantity of yarn.

A part of the depth of the socket is to provide for irregularities in grade, and for all slight changes in direction. If the end of the spigot is drawn away from the bottom of the bell on one side only one-eighth inch for each two inches of the diameter, a change of direction of three and one-half degrees is made. Perhaps that is nearer to a straight line than the work can be done in many of the hilly streets of New England cities; but in some places, all street work is now laid out with so much care that a line of pipe can be laid within that limit.

The curve of large radius, shown at the bottom of the bell in the drawing, is correct for the design of special castings cast in green-sand molds; but the method of making the different parts of a dry-

sand mold for straight pipe cast bell end down is such that a shape like that shown must be made with the trowel, — extra work, for which the socket maker is not paid and so seldom does. The bead at the spigot end can be made in a shape to correspond, with advantage to both maker and user. The change in the bead suggested is a triangular instead of a nearly half-round shape, when shown in section, — the largest diameter through the bead being nearly at the end of the pipe, and the end nearly square across. When joints are made with pipes having the sharp corners suggested, instead of a round-cornered design, there is more room for the yarn, and a smaller quantity can also be used with more confidence that it will not let the lead run through, so that less depth of socket is required.*

Under the present high-pressure methods, cast-iron pipes are generally shaken out of the molds too hot — often red. It would be hard to say just how much difference this makes; but there can be no doubt that cooling quickly causes the crystals of cast iron to be inferior in quality, and sometimes a condition of strain within the casting itself. The writer has seen a 30-inch pipe, one and one-eighth inches thick, crack open in two places, from one half to two thirds its length, at the bell end, when under less than three hundred pounds pressure, the sides of the cracks at the end of the pipe remaining rigidly about one and one-half inches apart. It was a pipe shaken out while still red; and there appeared to be no other reason for its behavior than the unequal contraction in cooling. This pipe had been rejected because the same condition had been indicated by its being badly out of round.

Some foundries practice the making of two pipes in the same flask in one day; others one per day, while others have provided two full outfits of flasks and core-bars, and make casts in them on alternate days. The pipes remain in the flasks over night, and are perfectly cold when shaken out. This process must give the best quality of pipe, other conditions being the same. As all the flasks and core-bars are of the same temperature when the new molds are made, the pipes are more uniform in weight. Many of the defects of casting are thus avoided.

It is provided that specimen bars shall be cast without charge. It would not be too much to specify that the use of a standard testing

* See "A Discussion of Pipe Joints," submitted by Mr. Manning for the February meeting, and printed on page 130. — EDITOR.

machine for breaking the bars should be furnished by the contractor. Otherwise it might be held by him that the clause that provides that he shall furnish the tools for the inspection of pipes did not cover the machine for breaking specimen bars. The breaking of these bars is not of vital importance, but it is thought that by means of it a better knowledge of cast iron will be gained by all concerned.

It is desirable also that the Association should, if possible, do something to promote the chemical examination of the mixtures for cast-iron pipe. A case in mind is what occurred at a foundry where nothing but 30-inch pipe were being cast. The mixture put into the cupola was brought from four different furnaces. For a thickness of seven-eighths inch and one inch the castings were good and sound, but for a thickness of one and one-eighth inches, less than ten per cent. could be accepted for several days at the start. The castings were porous and leaked badly through two or three feet of the pigots (upper) end when proved. This could not be helped by the inspector or buyer, but it was not pleasant for them to have it occur.

It is the writer's observation that good large and thick pipe cannot be made with the iron that will make good small pipe.

The metallurgical chemist's knowledge of steel is such that contracts are made which specify what per cent. of carbon and other ingredients it shall contain, according to the purpose for which it is to be used.

The large scale processes of making steel, such as the Bessemer open-hearth, or basic, have always been, and the reduction of the ores in the furnaces is now, as a rule, under the direction of metallurgists, and is conducted in a scientific manner.

The iron-founder's art is older than the science of chemistry. Its processes are still based largely on the traditions of the art. The services of a chemist are seldom employed. The olden-times iron-founder, who could tell all about cast iron from the appearance of the fracture of the pig, was successful as long as the pigs were all from the same ores and furnaces, but was at a loss when it came to using unknown pig iron.

It is to be hoped that the time will come, and probably the time is coming, when there will be a chemist in charge at the pipe foundry.

However valuable he might be to an ordinary foundry business, he would be particularly useful at a pipe foundry where the quantity

of iron used is large, a great many castings of the same size and thickness are made, and nearly all of the work is done by men who are to be classed as common laborers when compared with the molders in green sand. Such conditions are favorable for a scientific management. A metallurgist, trained in pipe making, would know what is needed to make a certain line of castings called for by a contract. He would select the mixture and give it the heat treatment needed. Instead of running the whole foundry force for several days on experiments, turning out pipes which are sent to the scrap-pile or accepted reluctantly by the inspector, the castings would be from the beginning as sound as the best made under the usual practice of the present.

The largest consumers can now make contracts for pipe under such specifications for the design, mode of casting, inspection, etc., as they wish.

By the use of standard specifications, adopted by this Association, the smaller consumers will be able to obtain, even for their yearly extensions, first, pipe that will always fit together; second, a saving in material and cost, through a better and a uniform design; third, an improved quality, by insisting upon the important clause that the pipe shall be cast bell end down, and not giving permission in writing for bell-end-up casting, except it may be for 4-inch pipe.

To obtain pipes of even thickness, free from defects and properly proved by hydrostatic pressure, it will always be necessary to have the services of a good inspector.

A DISCUSSION OF THE DESIGN OF LEAD JOINTS FOR CAST-IRON WATER PIPE.

[*Submitted for the February meeting of the Association, by George E. Manning.*]

Years ago, when the hub and spigot form of cast-iron pipes with lead joints was adopted, it was the practice to make the depth of socket much more than it is made now.

Twenty-five to thirty years ago, many miles of pipes were laid which had a depth of socket as small as two inches for the six-inch size. That was a bold departure from the general practice, but it does not appear that these joints have given any more trouble in service than the deeper ones have. But it was found desirable to increase the depth slightly, chiefly because hilly streets have made it necessary to have small deflections in a line of pipe.

All engineers came to have more confidence in the lesser depth, and a general tendency in that direction is to be noticed in all designs of late years, probably not so much in the larger as in the smaller sizes. But, as the greater part of the large sizes are under less pressure (that is, in gravity systems, perhaps not in pumping systems), they are less subject to water hammer, and, as a rule, can be laid in a more direct alignment, — curved pipes being used for changes in direction, — it would appear that a small depth of joint is as safe for the larger as for the smaller sizes.

Another consideration is, that for 24-inch and larger sizes, into which a man may crawl, a device can be placed on the inside of the joint that will keep the lead from running through, and thus do away with the yarning and the space that it takes up in the smaller sizes. This joint can be set up on the inside as well as on the outside, and thus affords better security.

As there are many members of the Association who have used, prefer to use, and will probably continue to use, a design for pipe having a depth of socket less than that suggested by the Committee on Standard Specifications for Cast-iron Pipe, a design and table of dimensions which embody this idea are submitted for consideration. It is based on the design of Mr. J. Herbert Shedd, which is in use at Providence, Newton, and many other places.

The dimensions shown will give at least two inches for depth of joints (including bead, yarn, and lead, as such), with a deflection of not more than three and one-half degrees in the alignment.

The tangent of $3\frac{1}{2}°$ being .06145 or $\frac{1}{16}$, one-eighth inch for each two inches of difference in the diameters is taken for the difference in depths of sockets.

Beginning with a depth of $2\frac{1}{8}$ inches for a 2-inch pipe, a 4-inch pipe will have a socket $2\frac{1}{4}$ inches deep, a 6-inch pipe, one $2\frac{3}{8}$ inches deep, etc. All changes in the corresponding outside dimensions of the hub for changes in diameter have the same relation to the depth of socket.

By having the inside of the pipe flare out a little larger at the joints, the waterway of the pipe line is not reduced when the pipes are not exactly centered from any cause. This flare can be easily made at the hub end, and seems to be worth having. A flare at the hub end only gives all the benefit in case the pipe is laid with the hub end toward the flow of water, and much of it in any case. As the flare at the spigot end is more trouble to make, and would

lead to more breakage in the thinner classes, it might not be well to insist upon it in all cases.

The function of the bead at the spigot is to keep the yarn from being driven through the joint when it is being calked. A shape like that shown tends to place the yarn exactly where it is needed and to resist its going any beyond. A half-round shape of bead will tend to let the yarn slide around it into the pipe. The mold for a pipe has to be parted at the largest diameter of the bead. When the part of the mold that forms the end of the pipe is flat, or nearly so, it can be made in a more economical manner by the foundrymen than the half-round shape can be.

Attention has already been called by the writer, in a previous discussion, to the nearly square inside corner of the socket. The slight slant at the end is the shape usually given to it by the socket core-maker, as it is thought that it can thus better resist the blow from the molten iron, falling from a height of twelve feet upon it.

If any lot of cast-iron pipe is examined, it will be found that the outside of the hub joins the shaft of the pipe with a slight offset and not with a tangent curve. The pattern is parted at that point, and if the hub pattern was given the thin knife edge when it was made, it would soon be broken so as to produce the offset in the casting. It will also be found that the straight parts of the sides of hubs are at an angle and not parallel with the shaft of the pipe. This is in order that the pattern may be drawn easily without breaking the mold. It may be of interest to state that the upper end of a pipe is a little larger in diameter than the lower end, for the same reason.

There has been a great diversity of ideas shown in the design of the lead groove. Many miles have been laid with pipe that had perfectly straight joints, *i. e.*, with no lead groove at all. A groove half-round in section has been used, which is probably, when set up, of no more use than no groove, and a waste of lead. A great many pipes have been laid that have a groove which is the reverse of the Boston design, — that is, the lead has to be set up against the shorter slant. Such a joint would seem to give the calker a harder task to set up the lead in its place than it gives the water to push it out of place.

The design shown has a groove with a slant on each side of the same length, viz., seven-eighths of an inch.

The length, over all, of a pipe is always made the same as the length of the flask in which it is cast, so that of two designs cast

at the same foundry, the one which has a hub that is, say, one inch shorter than the other, will have a laying length one inch greater.

Probably most men have not become trained to think in decimals of an inch, but mentally reduce such given dimensions to eighths and sixteenths. It is also doubtful if a pattern maker's shrink rule, divided into inches, decimally, is often found at a pipe foundry. There, too, such dimensions are changed, for use, into the common fractions. If any change is to be made in the direction of a decimal system, would it not be well to consider the metric system, which is coming into use in the shops, and will be in general use by machinists, probably, sometime?

Five centimeters are nearly equal to two inches. A pipe twenty centimeters in diameter would be only one-eighth inch smaller than an 8-inch pipe. By providing for a thicker class, — which would be seldom or never used, — the outside diameter being the same for all classes, as specified, the objection of a reduced capacity would be avoided in all ordinary cases. Fifty centimeters would be five-sixteenths of an inch less than twenty inches.

It would thus appear that a change could be made to the metric system with almost no inconvenience in any way. The new standard pipe would joint with the old as well as pipes from different foundries will with each other now. The difference between sizes, being five centimeters instead of two inches, would be as easy to carry in the mind.

In the table of dimensions which follows, outside diameters are not given, as they depend upon the thickness of the heaviest class that is decided upon finally. The inside diameter of the socket also depends upon the thickness.

$$\text{Depth of socket, } \begin{matrix} D = 2 + \dfrac{\text{Nominal diameter}}{2 \times 8}. \\ A = \tfrac{1}{2}\, D. \end{matrix}$$

Thickness of end of hub $B = D - 1$ inch up to the 18-inch size, for which it is $2\frac{1}{2}$ inches, which is considered to be about as thick as there is any advantage in making it. But an increase of $\frac{1}{8}$ inch for each six inches on the diameter is suggested for the larger sizes.

$C = \frac{1}{2}\, B.$

Radius $E = \frac{1}{2}\, B - \frac{1}{8}$ in.

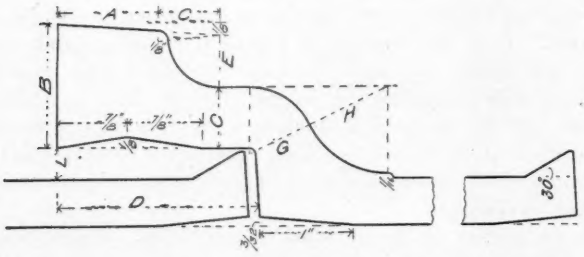
" $G = \frac{1}{2}\, B + \frac{1}{16}$ in.

" $H = \frac{1}{2}\, B + L - \frac{1}{16}$ in.

L = thickness of lead joint.

The recess of the lead groove should be from $\frac{1}{8}$ inch in depth for the smaller to $\frac{1}{4}$ inch for the larger sizes.

TABLE OF DIMENSIONS FOR HUBS, IN INCHES.



Nominal Diameter	4	6	8	10	12	14	16	18	20	24	30	36	42	48
Depth of Socket	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3	$3\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{7}{8}$	$4\frac{1}{4}$	$4\frac{5}{8}$	5
B	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$
A	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{9}{16}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{15}{16}$	$2\frac{1}{8}$	$2\frac{5}{16}$	$2\frac{1}{2}$
C	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{16}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$1\frac{3}{8}$
Radius, E	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	$\frac{15}{16}$	1	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$
" G	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$		$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{7}{16}$
" H	$\frac{13}{16}$	1	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{11}{16}$	$1\frac{3}{4}$	$1\frac{13}{16}$
Thickness of Lead, L	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Outside Diam. of Pipe														
Inside Diam. of Socket														
Class A { Thickness														
Class A { Weight														
Class B { Thickness														
Class B { Weight														
Class C { Thickness														
Class C { Weight														

Hubs for special castings to have the same dimensions, except for depth of socket, which shall be one inch more, in all sizes.

MR. HORACE G. HOLDEN. I would like to ask Mr. Brackett what was the cause of the break of the large pipe on Causeway Street, in Boston, near the Union Station, some time ago: whether it was due to a defect in the casting originally, or whether the defect was caused in moving the pipe from the foundry to the cars, or in transportation on the railroad, or in moving it from the cars to the street, or in the laying of it.

MR. BRACKETT. That was a case where the pipe had been laid for many years in a soil which is more or less marsh mud, and the iron had deteriorated very much and turned to plumbago. I have had many cases in my experience where it has been very difficult to determine the cause of the break. Pipes that have been in use for a great many years without showing any visible indication of weakness have burst. There were about half a dozen breaks in the city of Boston last year on a line of 48-inch pipe which was only under about fifty or sixty feet of head, and the pipes were an inch and a quarter thick. These pipes should have withstood two hundred or three hundred pounds pressure. They had been in use since 1869, but not under quite as much pressure. A number of theories have been advanced as to the cause of the breaks, among others that slight cracks had been caused at some time by water hammer which were developed by the additional pressure.

MR. R. C. P. COGGESHALL.* Brother Holden may be interested in a case we had in New Bedford last April. It was on a 30-inch pipe, which had been laid in connection with our new works and was about two and one-half miles from the city. It had been thoroughly inspected. The pipe was fully an inch thick, and there was no way of accounting for the break, that I could see. There was a piece about five feet long and about two and one-half or three feet wide on the lower quarter blown straight out, just the same as you would take a cover off a stove, and there was n't a sign of a crack on the remaining part of the pipe. I have n't the slightest idea what the cause was.

MR. CHARLES K. WALKER.† I can tell you a story which I think will beat that. Last summer one of our gates, probably as good a gate as there is made, cracked from top to bottom under about one hundred pounds pressure. We had shut it off, and were repairing on the line below when the report came that there was a leak, and we went up and found the gate split from top to bottom right through the flange — an inch and a quarter flange. I have asked a good many experts what they thought about it, and they have all told me it was one of those cases which they did n't know about. I made up my mind I did n't know, and I can't find anybody so far who does. Now, if there is any gentlemen here who can tell me, I will treat him. [*Laughter.*]

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* Superintendent of Water Works, New Bedford, Mass.
† Superintendent of Water Works, Manchester, N. H.

A MEMBER. Which way did it crack, up and down or horizontally?

MR. WALKER. Up and down. The gate had been shut for two hours, and all at once there was this big leak. We happened to be working near by, so we could shut it off, and there was n't any harm done.

MR. HOLDEN. How large a gate was it?

MR. WALKER. Twenty-inch. There was no wedging about it, and the iron was an inch and a quarter thick. There is another thing I want to say, about inspectors. We had about twenty-five leaks on a half a mile of 20-inch pipe, and the inspector who inspected it when it was laid is right here under my eye, and he is a good, bright man. [*Laughter.*] When we went to drive in the lead in a 4-inch bell, it went 'way in. We had to hustle round to shut it off when we struck it, because it was pretty full of gasket and there was mighty little lead. Of course the contractor was n't to blame, nor the inspector, — but there it was. If there had n't been but a little gasket in there we should n't have had any trouble. I am for a good, deep bell and plenty of lead. I don't care anything about the theoretical part of it, but any man who has had experience will say he had rather have more lead and less gasket. I want a 4-inch bell on a 20-inch pipe. I have seen enough trouble with short bells. A man who has been a superintendent for a number of years knows what trouble is when he gets it, but when you tell these experts about these things and ask them what is the cause, they say they don't really know. [*Laughter.*]

MR. F. F. FORBES.* I would like to ask Mr. Walker one question about the pipe line below the gate. How many feet fall was there, and was it abrupt?

MR. WALKER. I should think there was about thirty feet of fall.

MR. FORBES. I once had a similar experience to Mr. Walker's. I shut off the main where there was quite a sharp fall in the pipe, and the gate at the upper end of the main broke, something like in Mr. Walker's case. At first I could n't understand the reason for it, but I finally figured it out in this way: There was more than thirty-two feet of fall from the gate to where the blow-off in the main was, and when we opened the blow-off the whole column of water left the gate and very nearly a perfect vacuum was formed. Then for some reason or other that column of water broke, and this body of water went back like a cannon ball and struck the gate and

* Superintendent of Water Works, Brookline, Mass.

shattered it to pieces. This happened where there was n't more than fifteen feet head back of a gate made by the Boston Machine Company in 1874, a very heavy gate, one of the heaviest patterns. The gate was shut down carefully by hand, and there was no pressure whatever on the gate in turning it. The gate was broken to pieces, and the only explanation I could find was what I have stated.

MR. WALKER. I am very much obliged to the gentleman for telling me what the trouble was. He is the first one who could do it, and my offer to treat holds good. [*Laughter.*]

MR. H. A. FISKE. I should like to ask one question, which has been suggested by this water-hammer incident, in connection with some trouble we have had recently in a New England town from excessive water hammer caused by interior fire protection. I never knew of anything like it before, although we have fire protection devices of the same nature in other places. The water-works people in this town have had trouble from breaks caused by water hammer, and they claim that the device, which is a sprinkler system with air in the pipes, should not be allowed to be used, because it causes water hammer. The other side of the question is that the water hammer is not excessive, and is not more than is obtained in other places. I thought if any gentleman here had known of trouble from water hammer caused by fire protection devices, it might be interesting to bring the matter up. If the difficulty is with the device, and the water hammer is something which is going to cause trouble in other places either now or later on, I think we would all like to know it. I don't know as I have made myself clear, but I was wondering whether any of you gentlemen had had experience with water hammer causing breaks, and had taken action against devices, perhaps not fire protection devices, but elevator devices, or things of that kind.

MR. WALKER. I inspected the working of an hydraulic elevator in Worcester once, and the pressure went up from three hundred pounds to one thousand pounds, due to water hammer. I told them we did n't want any such thing as that in Manchester, for water hammer on cement pipe isn't healthy. [*Laughter.*]

MR. FISKE. Do you know of any action ever being taken by any water-works company in this matter? I should think the case you mention was rather exceptional, and I refer to a moderate water hammer, perhaps of two hundred pounds.

MR. WALKER. No, I never knew of any.

MR. FISKE. I should think the water-works people would feel like sitting down on any device which causes excessive water hammer.

NOTE. — As stated on page 113, the manufacturers were to hold a meeting on January 16, at which they were to formulate their position; but a statement of their views has not yet been received from them, although requested several times, and each time promised "in a few days." — EDITOR.

THE MARLBOROUGH WATER WORKS.

BY GEORGE A. STACY, SUPERINTENDENT, MARLBOROUGH, MASS.

[*Read February 12, 1902.*]

The first action taken by the town of Marlborough towards introducing a public water supply was in 1873, when a committee was chosen to take the matter under consideration, and they secured the services of the late Phinehas Ball, C. E., of Worcester, and reported in 1874.

This report recommended a pumping station, distributing reservoir, fifty hydrants, and about eight miles of cement-lined pipe.

The attempts to introduce a public water supply met with the usual vicissitudes common to such undertakings, until 1882, when decisive action was taken and the work commenced, and the late M. M. Tidd was retained as engineer.

The city of Marlborough is situated at a considerable elevation above the immediately surrounding country, and the west end is built in part on four hills, viz., Prospect, Fairmount, Mount Pleasant, and Sligo; the last is the highest, and is about six hundred feet above tide water, and situated in the northwest part of the built-up part of the city; it is two hundred and sixteen feet above Main Street, at City Hall.

At the southwest base of Sligo Hill, and distant about fifteen hundred feet from its summit, is Lake Williams, a natural body of excellent water, the surface of which is about forty feet above Main Street, at City Hall (see plan, Fig. 1).

Considering its elevation, the city was very much favored by nature in regard to a public water supply, with one exception, and that was the quantity, — the watershed of Lake Williams being only two hundred and nineteen acres. But as all other suitable supplies were from two and one-half to five miles distant and at a very much lower level, and as Lake Williams would in all probability furnish a supply for a number of years at a comparatively small cost, it was decided to take this supply.

A pumping station (now called Station No. 1) was built on the

north shore of the lake; a reservoir of five and one-half million gallons capacity was constructed on Sligo Hill, ten miles of distributing mains were laid, and the water was turned on Main Street, on July 1, 1883. This work, and five miles of pipe laid in 1884, was done by contract; since that time all work except Pumping

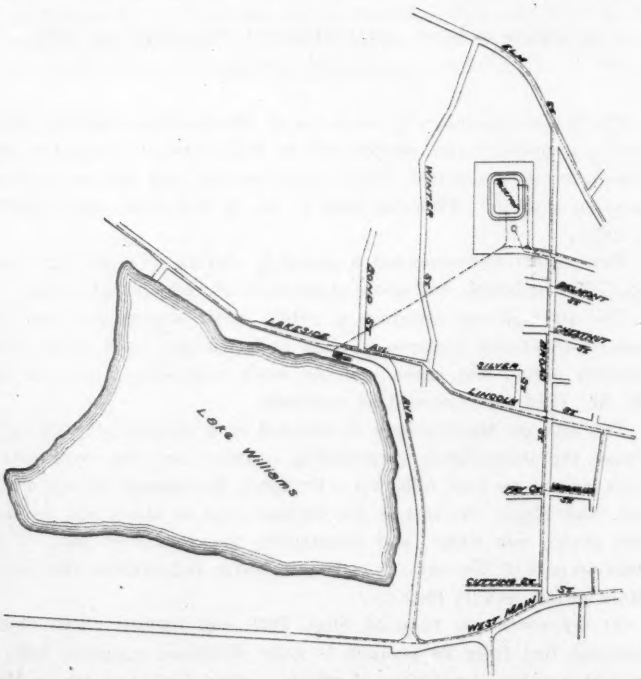

FIG. 1. — PLAN OF LAKE WILLIAMS, SLIGO RESERVOIR, AND CONNECTING PIPE LINES.

Station No. 2 and the standpipe has been done by the city with day labor.

In 1891 the low water in the lake demonstrated that we had about reached the safe limit of our supply, especially in a series of dry years.

After investigating all the available supplies and conferring with the State Board of Health, it was decided to construct a reservoir on Millham Brook in the northwest part of the city (see Fig. 2).

This brook, with its north branch, has a drainage area of about three and one-half square miles, which is very sparsely populated.

The dam was constructed of earth with a concrete core wall. It is 1 160 feet long on top, with a maximum height of twenty-six feet; the foundation of the core wall is on bed rock and in hard pan, and its maximum depth is twenty-five feet below the surface. A thirty-inch pipe extends through the south end of the dam on a level with the bottom of the reservoir.

The north end of the dam abuts on a ledge which rises from ten to fifteen feet above the top of the dam, and by the removal of about

FIG. 2.

one thousand cubic yards of rock, a wasteway was cut through this ledge. Fig. 1, Plate I, is a view of the dam, and Fig. 2, Plate I, shows the wasteway.

A pumping station, called Station No. 2 (see Fig. 1, Plate II), was built on the south shore of this reservoir. In this station is a high-duty Worthington pump of two and one-half million gallons

capacity, and two boilers, sixty inches in diameter and sixteen feet long, built for a working pressure of one hundred and twenty-five pounds. The head against which the pump works when pumping to Sligo Reservoir is 408 feet.

The water of Millham Brook enters the reservoir at the point marked "*A*" on the plan, Fig. 2. Forty or fifty years ago this was the site of a small sawmill such as were common in those days, and part of the small dam only remained. As it was probable that we should be in need of more water than Lake Williams could furnish before the new reservoir was completed, advantage was taken of the situation, the old milldam was rebuilt, and a pipe about fifty feet in length was laid from the small basin thus formed to the gate chamber of the pump well, and we were able to pump a limited amount from this source in the spring of 1893.

The force main from this station is two and one-quarter miles long, passing through private land for one half of the distance, the balance being in Northboro Street and Lakeside Avenue, which passes directly in front of Station No. 1 at Lake Williams.

The force main from the latter station crosses the avenue at this point, and the two mains are connected here by a Y-branch; between this connection and Station No. 1 is a four-way branch, with four gates controlling all the outlets (see plan, Fig. 3).

After crossing the avenue, the original force main passes northeast through private land for about twelve hundred feet, and enters the south end of Sligo Reservoir grounds, passing east through these grounds in a continual line to Broad Street (at this point it becomes the main distributing pipe); then south on Broad Street to Lincoln Street, then east down Lincoln Street. Lincoln Street going west forms a junction with Lakeside Avenue, near Station No. 1, as shown in Fig. 1.

From the east outlet of the four-way branch on the force main in front of this station, a pipe is laid over Lincoln Street to the junction of Lincoln and Broad streets, and connects with the main distributing pipe (see Figs. 1 and 3).

From a Y-branch on the force main in the reservoir grounds a pipe leads to the south end of the reservoir, discharging at high-water level; at the outfall of this pipe is a flight of stone steps for the water to fall over; there is a gate on this line, and one on the main just east of the Y-branch.

About two hundred feet east of this point, the pipe line leading

FIG. 1. — MILLHAM DAM, LOOKING SOUTH.

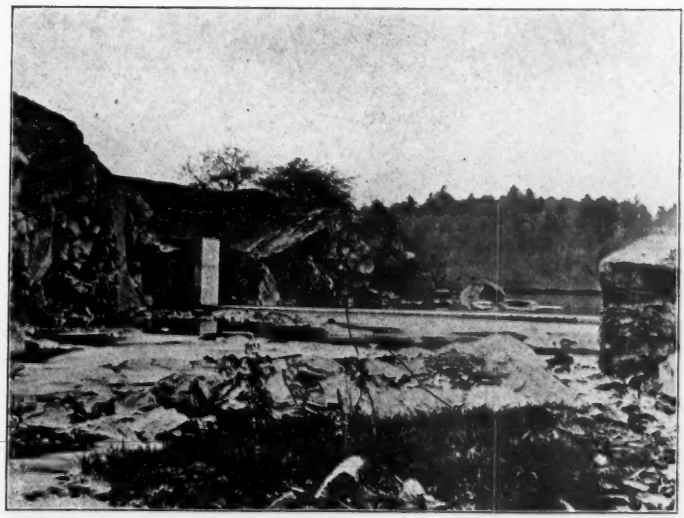

FIG. 2. — WASTEWAY, MILLHAM RESERVOIR.

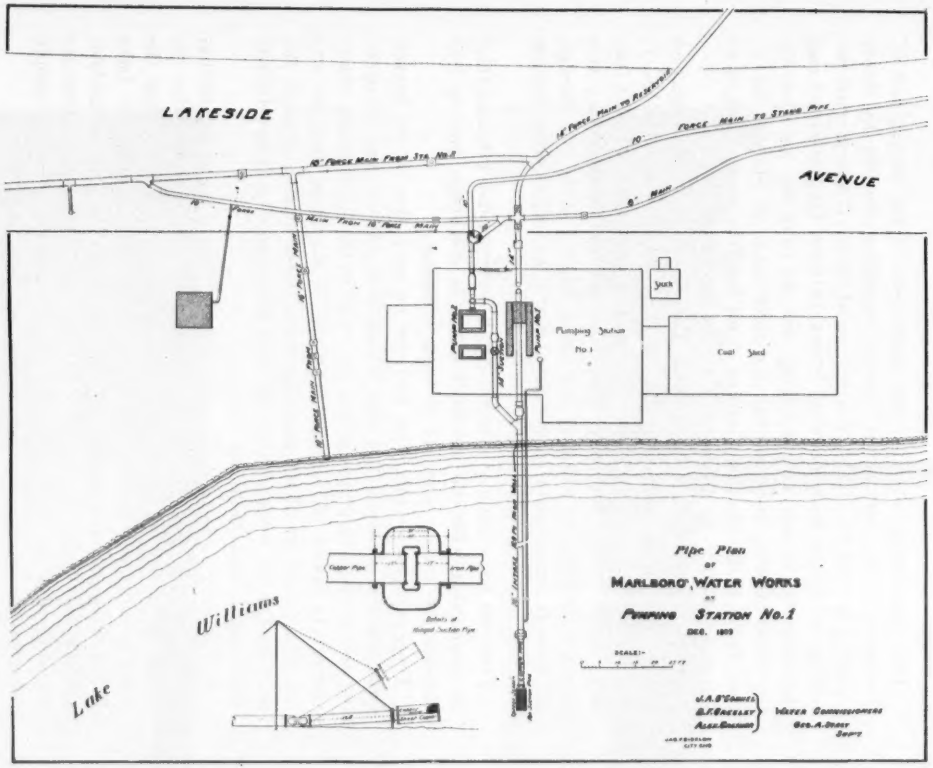
LAKESIDE
AVENUE
10" Force Main from Sta. No. 2
16" Force Main to Reservoir
10" Force Main to Stand Pipe
8" Main
Main from 10" Force Main
8" Force Main
Pumping Station No. 1
Coal Shed
Yard
Williams
Lake
Pipe Plan
of
Marlboro' Water Works
at
Pumping Station No. 1
Dec. 1909
Scale:-
J. A. S'Comes
B. F. Bressler
Alex. Bowman
Water Commissioners
Geo. A. Gray
Supt.

Fig. 3.

from the gatehouse is connected with this main, with a gate on each, set near their junction. The gatehouse is on the north end of the reservoir.

This combination of pipes and gates permits the cutting out of the reservoir for cleaning or repairs, supplying the city by direct pumping through two lines, or either one of them; it also permits the cutting out of the main on Broad Street, between Lincoln Street and the reservoir grounds, and supplying the city from the reservoir by the water passing back through the force main to Station No. 1, then through the pipe line leading from the four-way branch, over Lincoln Street, to the junction of Broad and Lincoln streets.

On the force main from Millham Reservoir, about one hundred feet west of its junction with the old force main at Station No. 1, is a Y-branch, from the outlet of which a pipe connects with the west outlet of the four-way branch on the old force main; this forms a by-pass, by which we can pump directly to the city through the Lincoln Street main from Station No. 2, as well as from Station No. 1.

From the force main of Station No. 2, between the Y-branch and its connection with the old force main, a discharge pipe is laid through the station grounds to Lake Williams.

There is a gate on this pipe, and one on each side of the branch from which it is taken; this pipe is used as a blow-off, and by opening and closing the proper gates, the water in the distributing reservoir can be drawn off into the lake, and at the same time the city can be supplied by direct pumping from either station through the main on Lincoln Street; it is also used when pumping from Millham Reservoir to Lake Williams.

If the water in Lake Williams is at high-water mark in the spring, it will furnish a supply for the season; and to accomplish this the pumps at Station No. 2 are run in the winter and spring (when the water at this place is at its best) until the amount pumped to Lake Williams, together with what it receives from its own watershed, assures this result. Station No. 2 is then put out of commission for the balance of the season, or until such time as an additional supply from this source is needed.

These conditions had an influence on the treatment given to the bottom of Millham Reservoir at the time it was built.

The shores of the reservoir are mostly steep, as shown in the view, Fig. 2, Plate II, and with but little shallow flowage; about

FIG. 1. — PUMPING STATION NO. 2.

FIG. 2. — MILLHAM RESERVOIR LOOKING SOUTH.

sixty per cent. of the bottom was meadow land, and along the course of the brook that flowed through it, the mud in places is quite deep; the balance of the basin was woodland.

Plans for stripping the whole basin were considered, as well as for covering that part where the mud was deep with sand and gravel taken from the hills that formed a large portion of the south shore of the reservoir.

The estimated cost of stripping the whole basin made by our engineer was from seventy to eighty thousand dollars.

The question of filtration was also considered, and it was thought possible that in the near future the advancement made in the construction and introduction of filters in this country might be such that this money, expended in filtering the water from all sources as it went to the consumer, would yield the greater benefit.

It was then decided for the present to strip only the surface from high-water mark out to a point where the water would be ten feet deep with a full reservoir, and to fill the shallow places with the material thus removed.

Under these conditions, using Lake Williams in part as a storage reservoir, we are able to select the best and most convenient time to pump from Millham Reservoir, and we have up to the present time secured a very satisfactory supply from this source; and the saving in interest has amounted to twenty-five per cent. of the estimated cost of stripping the balance of the basin.

The force main from Station No. 2 is laid to a hydraulic grade to within one-half mile of Station No. 1, where it reaches the summit; from this point to the station, at the point where the blow-off pipe discharges into the lake (Fig. 3), the fall is forty feet.

There is a considerable population along this line where it lies in the highway which is supplied from this force main, and when pumping into Lake Williams sufficient back pressure has to be maintained at the discharge pipe to supply the services on the summit.

At first, to accomplish this, the gate on the discharge pipe was partly closed, but we found that it was difficult to adjust this gate just right every time; and there was another difficulty, if not danger, in this method, for if, when the pumps were stopped, this gate was not immediately closed, the discharging water would cause a strong siphon action on the summit, and possibly draw air in through the service pipes, and cause trouble when the pipes were filled again.

As a secondary means to avoid this, a specially designed automatic gate was tried, but this proved a total failure.

I then designed the siphon now in use, which was constructed by inserting two three-way branches in the discharge pipe, where it passes through the station yard, spaced eight feet on centers, with the outlets on top, and with a gate set between them. Pipes rising two feet above the surface with flanges on top were set in these branches. The siphon is bolted to these flanges, and is constructed of spiral riveted galvanized iron pipe, and is forty feet high, or a little above the grade of the force main at the summit. A view of this siphon is shown in Fig. 1, Plate III.

A vertical check valve, inverted, was placed on the top of the elbow of the discharging leg of the siphon, to act as an air valve.

By closing the valve between the three-way branches, the water flowing to the lake must pass over the siphon, and this affords a free passage for water and a constant head, and the pumps at Station No. 2 can be stopped and started without danger to the pipe line.

When the pumps at Station No. 2 are stopped for the day, the gate near the main, on the discharge pipe, is closed, and the gate on the force main opened, thus connecting this line with the distributing system, of which it is a part at all times when the pumps at Station No. 2 are not running.

In cold weather, to prevent the siphon from freezing, the gate between the two three-way branches is opened, allowing all the water to drain into the lake.

Previous to the introduction of a public water supply, Marlborough had relied upon hand engines and small reservoirs for protection against fire.

After the water works were in operation, the hand engines were put out of commission, and the water for the extinguishment of fires was taken directly from the hydrants.

In 1894 the growth in the number and size of the factories, and other private and public buildings on the higher levels in the west part of the city, was such that the water pressure did not furnish adequate protection for that district, and steps were taken to improve this service.

The first cost, cost of maintenance and efficiency of steam fire engines, and of an independent pipe system supplied by a standpipe, were considered, and it was decided in favor of the standpipe system; and work was immediately begun upon its construction.

FIG. 1. — PUMPING STATION NO. 1, AND SIPHON.

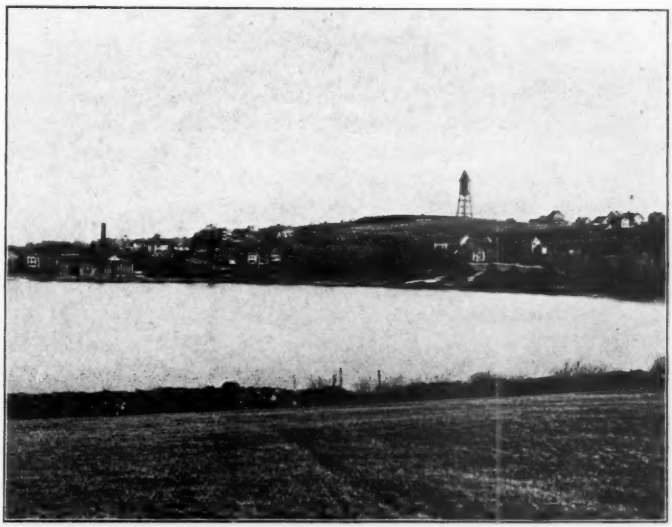

FIG. 2. — VIEW OF STANDPIPE AND SLIGO RESERVOIR, FROM THE SOUTH SIDE OF LAKE WILLIAMS.

This fire service consists of a standpipe, three miles of fourteen-, twelve-, ten-, and eight-inch pipe, thirty-two hydrants, and a Barr compound condensing pumping engine of about one and one-half million gallons capacity.

The engine was erected in Station No. 1 at Lake Williams.

The standpipe is located on Sligo Hill near the south end of the distributing reservoir; the tank is thirty feet in diameter and thirty-five feet high, with a conical bottom, and has a capacity of two hundred thousand gallons. A view of the standpipe is shown in Fig. 1, Plate IV. It may be seen in the distance in Figs. 1 and 2, Plate III. It is constructed of iron, with the round-about seams single riveted, and the vertical seams double riveted for the first fifteen feet. The conical bottom is made with butt-strap joints, with the butt straps on the inside, double riveted. A flange is turned up on the outer edge of the conical bottom plates, and is double riveted to the bottom sheets of the tank, and also to the steel channel plates that surround the bottom of the tank on the outside. This channel is riveted to the top of a plate girder three feet deep, which is riveted to the heads of ten steel columns seventy-two feet high.

A twelve-inch vertical pipe connects the tank with the ground main, and is protected with a double wooden jacket, with six-inch air spaces; the inside jacket is covered with hair felt one inch thick, which is held in place by brass bands.

A balcony surrounds the top of the tank, which is one hundred and ten feet above the ground.

The roof is cone-shaped, and the extreme height is one hundred and forty-six feet; situated on this elevation, it is a very prominent object.

The standpipe was designed by B. R. Felton, then city engineer of Marlborough, with F. C. Coffin as consulting engineer, and was built by Tippett & Wood, Phillipsburg, N. J. It has never cost a cent for repairs, except for the necessary painting, and is absolutely water tight.

It was the second one of this shape erected, and although smaller, was similar in appearance and design to the standpipe that fell at Fairhaven a short time ago.

This service is for fire protection only, and was designed to deliver ten $1\frac{1}{8}$-inch effective fire streams at any point on the system.

At a test made in April, 1894, ten $1\frac{1}{8}$-inch streams were used, the average length of hose to each line being two hundred and fifty feet. A gage, set on one nozzle of a four-way hydrant to which

three of the ten lines were attached, showed a loss of pressure varying from six to seven pounds. The static pressure at this point is eighty pounds, and the streams were thrown higher than the flagstaff on the four-story factory, at which the test was made (see view, Fig. 2, Plate IV).

The power and volume of the streams shown at this test, and at others made on different parts of the system, demonstrated to the citizens who witnessed them that this district had now an ample fire protection, and that it would take at least five steamers such as are used in cities of the size of Marlborough to duplicate this work.

To prevent this system from becoming useless by any possible accident or conditions that would cut off the supply from the standpipe or pumps, a connection was made between the standpipe and reservoir mains, at the reservoir grounds; a check valve was set in this connection, and a gate on each side of it.

Every manufacturing establishment in the city, with two exceptions, is protected by sprinklers.

In the district covered by the standpipe service, the sprinklers are connected to both systems; and to prevent the water flowing from the high to the low service, a check valve, enclosed in a manhole at the sidewalk, is set in the pipe that connects the sprinkler system with the reservoir service.

At first I had some doubt as to these check valves working satisfactorily under all conditions, but up to the present time they have never caused any trouble; they open freely and close tightly.

There being no water drawn from the standpipe except in case of a fire, except that due to leakage or the breaking of a sprinkler head once in a while, it was thought necessary that some method be adopted to prevent it from freezing. For this purpose the force main of the reservoir and that of the standpipe were connected in the basement of Station No. 1 by a one and one-half inch pipe, controlled by a gate valve; the difference in pressure on the two mains is fifty pounds, and upon opening this valve the water flows from the standpipe to the reservoir main and thus keeps up a circulation. When the water in the standpipe is drawn down about three feet, it is pumped up again.

That this was a necessary precaution was shown by a little incident that happened the second winter it was in operation.

One cold Sunday morning I was called up to the station, and the engineer informed me that the night before when he pumped up the

FIG. 1. — SLIGO RESERVOIR AND STANDPIPE.

FIG. 2. — TEST OF FIRE STREAMS FROM STANDPIPE SERVICE.

PLATE IV.

standpipe he closed the valve on the by-pass (as was usual at that time), and forgot to open it again, and as the gage on the Barr Pump showed only reservoir pressure, he was afraid the standpipe was frozen up. Opening the relief valve and getting no response from the tank proved that this was so.

After carefully considering the matter, I concluded that the first place to freeze would be where the top of the wood jacket butts against the conical bottom, the cone being of small diameter at that point and unprotected, and its shape would be favorable to the removal of any obstruction by pressure applied underneath. Believing that the pipe lines were perfectly safe at two hundred pounds, I decided to try the experiment of forcing the ice up.

Starting up the pumps, I slowly raised the pressure on the force main until the gage showed one hundred and forty-five pounds, after which it slowly dropped back, and the pumps began to speed up, and I then knew that I had broken the ice, or something else. It proved to be the ice; and we have never had any trouble from that cause since.

It is now a standing order that the valve on the by-pass shall never be closed, from the time it opened in the fall until it is closed for good in the spring.

A Winslow recording gage is used to indicate the height of water in the standpipe, and has never failed to work satisfactorily.

The works at this time consist of two storage reservoirs with all their tributaries and water rights, with an aggregate storage capacity of about eight hundred million gallons, and four square miles of tributary watershed; two hundred and twenty-five acres of land from which we removed a number of dwellings, barns, outbuildings, and ice houses — and the city now owns and controls all the land around its reservoirs, and has paid, for land, land damage, and water rights, over one hundred thousand dollars; a distributing reservoir of a capacity of five and one-half million gallons, and a standpipe holding two hundred thousand gallons, both of these situated in Reservoir Park, on Sligo Hill.

The view from this place is unsurpassed in this section, the land sloping away in all directions to the surrounding valleys, in which are located a number of towns.

To the naked eye, the view extends from Mount Monadnock, in New Hampshire, on the north, to the Blue Hills of Milton on the south; from Bunker Hill Monument on the east, to Rutland, called

the center of the state, on the west; and, with a telescope, forty-five towns and villages, and a number of reservoirs and standpipes, can be seen.

The works also include Pumping Station No. 1, which contains two eighty horse-power boilers, one two-million Blake, and one one and one-half million Barr compound condensing pumping engine; Station No. 2, with two eighty horse-power boilers, and a two and one-half million Worthington high-duty pumping engine; 37 miles of distributing pipe; 344 hydrants, with a pressure of from 30 to 142 pounds; 386 gates; 1 200 meters, and 2 250 services.

The net cost of construction has been $586 645, and the net debt is $372 251.

The original works were designed by and constructed under the late M. M. Tidd, C. E., and the Millham supply and standpipe system by B. R. Felton, then city engineer of Marlborough.

During the nearly nineteen years of operation, the works have met every demand made upon them in a most satisfactory manner, and have proved an excellent example of water-works construction as produced by the engineers of to-day.

THE DECISION IN THE DAYTON ELECTROLYSIS SUIT.

[*Reprinted from "Engineering News" of April 17, 1902.*]

A partial victory has been won by the city of Dayton, Ohio, in its electrolysis suit against the City Railway Company. Mr. O. B. Brown, judge of the Court of Common Pleas of Montgomery County, has refused to order the street railway company to install the double-trolley system, as urged by the city, but says the company has been negligent in the operation of its road and must conform to the best standard practice of operating single-trolley lines.

The trial was a lengthy one, the experts were numerous, and there were many exhibits and several experiments before the court. The decision of Judge Brown occupies two full pages of the Dayton *Herald* for April 5, 1902. A large part of the opinion deals with purely local questions, and the findings of the court hinge largely upon the nature of the franchise granted by the city to the street railway company. The decision, therefore, has only a general bearing upon the electrolysis question in other cities, and, it is to be remembered, is subject to review in the higher courts.

After a detailed review of the contentions of the city and the company, and of the law on the subject, the judge concludes that a contract existed between the city and company "for the construction, operation, and maintenance of a single-trolley electric railroad."

Another point made by the judge was that the city had never attempted to compel a change in the method of traction by the exercise of its police powers, and that the court had no authority to exercise such power. For this and other reasons the judge held that even if the facts showed that the double-trolley or the underground conduit system was the only method of preventing the destruction of the water mains by electrolysis, yet the law would not permit him to order the adoption of one or the other mode of traction.

The first trolley line in Dayton was installed in August, 1888, "but the present system of operation did not become general until the early nineties." The first line, it appears, was owned by a company other than the defendant in this suit, and the first noted instance of electrolysis was upon a lead service-pipe, near this same early line,

found in 1893. That same year, Mr. Charles E. Rowe, secretary of the Dayton water-works, was sent to the Milwaukee meeting of the American Water-Works Association, where, the judge says, "The question of the electrolysis of water pipes was first publicly discussed."

Both sides to the suit admitted that the water pipes of Dayton are being damaged by electrolysis, but they did not agree as to the extent of the damage. During the trial a six-inch water main broke, when, in the course of a fire, the pressure was raised from sixty to one hundred pounds. The broken pipe was, the judge says, —

> brought into court the following morning and examined by the experts for the first time in court. This showed that the pipe had been badly eaten away throughout its entire length by electrolysis; and indicated to the experts that the current was pretty uniformly distributed over the surface.

Rivers, canals, steam railways, and intersecting street railway lines, the judge says, conspire to make the return of the electric current to the power house unusually difficult in Dayton.

All the experts in the case testified that the defendant had operated its railway "in a very inefficient and negligent manner, and far below the present standard of the art." The bonding is very inadequate throughout. In fact, a chart introduced by the defendant raises "a doubt as to there being any good bonds on most of the system." The experts also agreed that the system of return feeders in use "is not sufficient for the economical and safe operation of the" railway. The ground plates in use are no longer considered good engineering.

The balance of the opinion, with the summary of findings, is given substantially in full, as follows: —

> The testimony in this case shows that the plaintiff is powerless to adopt any method whatever to protect its piping system. On the other hand, a single-trolley street railroad, such as the defendant operates, can adopt no method by which the tendency of the current to flow through the earth and on to the pipes can be entirely overcome. But I am of the opinion that by coöperation between the two, such a system could be adopted as would reduce the injury resulting from electrolysis to a minimum or negligible quantity, as the experts term it.
>
> The defendant claims, however, that no system would prove effective as long as the other roads continue to operate as they are, but the testimony shows that any preventive measure adopted by this company would reduce the liability to injury to that extent.

The rails should all be metallically connected by adequate bonding, and the bonding well inspected frequently, and heavy copper cables should be used to conduct the current across the bridges and under the steam railroad crossings and intersecting railroad tracks. Return feeders of sufficient conductivity should connect the rails at various points to the negative bus-bar of the dynamo. This would increase the conductivity of the rail path and induce a much greater quantity of the current to flow thereon.

The ground plates which are still in use by the defendant should be removed, thus reducing the tendency of the current to flow to the underground metallic structures.

Having corrected the system by proper bonding, and by proper rail return, there should be coöperation on the part of the water-works board in permitting to be placed, as may be determined, at the proper places, the necessary insulators in the piping system. A few or none may be required.

A system operated along these lines, without insulators or pipe connections to the rails or dynamo, has proven successful in Hartford, Conn., and in other cities where the conditions are somewhat similar to those existing in this city.

The officials of the city of Chicago have also acted upon this theory, and have passed an ordinance making it unlawful for "any person, firm, or corporation, owning, operating, or controlling any surface or elevated railroad or any street railway within the city of Chicago, upon which cars are now or hereafter operated, by electricity as a motive power, with a grounded return circuit for conveying electricity," to operate their system without a "metallic return circuit of such cross-section and conductivity for conveying the current so used as a motive power, that the maximum difference of potential will not at any time exceed one volt between any part of such metallic return circuit and any water pipes, gas pipes, or other metals not installed for the purpose of forming a part of such metallic return circuit, and that there will not be a variation in difference of potential exceeding one-half volt, between any two measurements made at the same time at points along and upon said metallic return circuit, within a distance of three hundred feet or less from each other."

Similar regulations have been made in other cities in this country, and general regulations have been adopted by the different British boards of trade and by what is known as the Bristol Tramways Act, and it is now generally considered by practical and scientific men that if a difference of potential not higher than about one and one-half volts is maintained in the positive district, and difference of potential not higher than about four volts in the negative district, the pipes will be practically immune from damage.

I am satisfied, from a careful consideration of all the testimony, that if these remedies are applied with intelligence, according to the present state of the art, it is possible to establish and maintain, by careful and frequent inspections and electrical measurements, such a return for the current of the City Railway Company as will practically protect the water pipes of the city, and be also a great saving to the railway company in the cost of operation.

SUMMARY OF FINDINGS.

Upon consideration of the entire matter, I have come to the following summary of conclusions as to the law and facts: —

This court has no authority in law to compel a change in the system from the single trolley to the double trolley, and, if the same was warranted by the law, the facts would not justify such a change.

The defendant has been and is operating its road in a negligent manner, causing continual damage to the water pipes of the plaintiff, for which the plaintiff has no adequate remedy at law, and cannot by any practical method prevent such damage.

It is no excuse in law, and the facts would not justify the defense that other electric lines in Dayton are contributing to this or doing like damage. (Spelling, Sects. 390–397. McClung *v.* North Bend Coke Co., 9 C. C. 259. Meigs *v.* Lister, 23 N. J. Eq. 199.)

It is therefore the duty of the court to enjoin the defendant from so operating its railway, and to compel it, within a reasonable time, to introduce such improvements in the system, in order that the operation of the single-trolley system authorized by the franchise and contract will be in accordance with the present standard of the art of operating single-trolley roads. The plaintiff shall coöperate to that end.

All matters of detail can be arranged between counsel and the court in the final order.

The costs will be adjudged against the defendant.

After the foregoing decision was rendered, counsel for the railway company addressed some remarks to the court, in which it was virtually stated that if the city would let the case stand, without appeal, it would do the same, and, of course, would also comply with the orders just given.

EDITORIAL DISCUSSION IN "ENGINEERING NEWS."

The decision in the Dayton electrolysis suit, reviewed at some length above, while in some respects disappointing to the water and gas fraternities, is nevertheless a signal victory for both the city of Dayton and municipalities at large. The decision recognizes, (1) that trolley currents improperly returned to the power house destroy water mains; and (2) that even when a street railway company has a contract with a city for a single overhead trolley system it must use every well-recognized means to keep its currents off the water and gas mains. The city fought hard to secure an order for a change from the single to the double overhead trolley system, or else to the underground conduit system. This, we think, was a mistake. We have always maintained that it is not the duty of a city to say how elec-

trolysis shall be prevented. The burden should rest wholly with the street railway companies. When a city attempts to say how the problem shall be solved, it assumes more or less responsibility for the success or failure of the remedy. It may even find to its sorrow that it has entered into a contract, and has thus debarred itself from otherwise possible relief. In the Dayton decision, the judge virtually declares that no matter how dangerous the menace from electrolysis, nor how effective a remedy might be found in the double overhead trolley system, the city cannot force the adoption of the latter because it has entered into a contract for the single overhead trolley. In the future, cities will do well to see that their street railway franchises do not cut them off from relief from damages to their own property. In addition, no street railway franchise should be granted hereafter which does not specifically provide that the system shall be so constructed and operated as to return the current to the power house without menace to underground furniture and without any other danger to life or property.

INVESTIGATIONS IN REGARD TO COLORING MATTER IN WATER AND METHODS OF REMOVAL.

[*Discussion, March 12, 1902.*]

PRESIDENT MERRILL. The first paper announced upon the program for the afternoon is by H. W. Clark, chemist, Massachusetts State Board of Health, on "Investigations in Regard to Coloring Matter in Water and Methods of Removal." I am sorry to tell you that a telegram has just been received from Mr. Clark announcing that he is too ill to be present with us to-day. We are very fortunate in having here, however, one of our members who is familiar with this subject, and it gives me great pleasure to call upon Mr. Desmond FitzGerald at this time.

MR. DESMOND FITZGERALD. Mr. President and fellow-members: I think it is little short of torture to be brought back at a second's notice from the old "Suwanee River" — where, under the spell of the sweet voices of our quartet, I was paddling down the stream in a canoe, thinking of the "old folks at home" who were waiting to welcome me to the cabin — and be asked to address a public assembly. [*Laughter.*] And yet I think I ought to thank our President for not having given me notice before the dinner began that I was to be called on, for, while in blissful ignorance of what was to follow, I have been able really to enjoy myself up to the present moment. The fact is, I always do enjoy these dinners of the New England Water Works Association very much, and I regret that it is not possible for me to be here oftener. As I look around the tables I notice some changes and a number of new faces. The most surprising change is in the head covering of some of our members, which seems to have become of a purer *color* as time has gone by, — partly accounted for, perhaps, by the fact that it is twenty years ago that the New England Water Works Association was organized.

While, as I have said, I am always glad to be here with you, I have sometimes thought I would never come to one of these public dinners again, because it always seems to fall to my lot to fill some gap. I know we all anticipated the pleasure of listening to Mr. Clark's paper, and it is a disappointment that we are not to hear it.

As I look around I see others here who could take Mr. Clark's place much better than I can, Mr. President. However, I presume something is expected of me now, and perhaps it may be of interest if I briefly review some of the history of this subject.

I remember very well that when the whole of Boston's supply came from Lake Cochituate there were no complaints about the color of the water. The color of the Cochituate water was about .25 to .30 on the Nessler scale. There were a good many complaints about the water in those days, however. Sometimes people could not brush their teeth with it, but that was n't a very serious thing, — they could get along without that, perhaps; sometimes they did n't want to bathe in it, and sometimes they certainly did n't want to drink it — but the color was all right. When the Sudbury River water was introduced for the first time, in 1872 or 1873, the works being completed from 1875 to 1878, that water was highly colored. I may remark, by the by, that the only reason why the Cochituate water was a light colored water was because it came from a lake so large in proportion to its watershed that the water became decolorized, or largely decolorized, by storage. We all know about that now, but we did n't seem to know so much about it in those days.

For a number of years we have been taking the colors of the waters in the brooks which feed the lake, and we know that the average color is something over 1.00 on the Nessler scale. That is reduced by storage to about .30. Then the Sudbury water came in from three small basins, in the first place, with a drainage area of about seventy-eight square miles, and that water was up to .70 and even higher, while the average color of the water running in the river was perhaps 1.00, as I remember it, about the same as that running in the brooks feeding Lake Cochituate. But of course we had to supply that water to the city at a very much higher color than the Cochituate, and people complained of it.

Now, I lay a great deal of stress on this matter of getting rid of the color in water, and it seems surprising to me to listen to the opinions of some people on this question of pure water, good water, that you are not ashamed to pour into a glass. For instance, look at the situation in Brockton to-day. There is a splendid great city, with intelligent men in it [*laughter*], and yet to-day they stick at the point of getting a first-class water, with almost no color, because it is going to cost a little more than a highly colored water. And there is that same fight right along that line almost everywhere.

Brockton can get the water of Silver Lake, which is a perfectly splendid supply, and you would think they would jump at it.

One step has led to another in the investigation of this subject, and we have made a careful study of it because it was so important in the city of Boston. I think I had the honor of conducting almost the first observations on an extended scale that were made in this line. The color of the water in the basins, brooks, and swamps on the Sudbury watershed was taken at many points every week for many months, and tabulated. We found that the water as it comes from the hills, before going into the swamps at all, has very commonly a color of .20 or .25 before it is brought in long contact with vegetation. We found that the water flowing from some of the hills surrounding Cedar Swamp, for instance, had a color of .25 and that after being held in the swamp, it would run up to 3.00 or 4.00. That led to the conclusion that the great cause of the high color in the Sudbury water was its being held in the swamps. Some of it comes from iron, but I think that for our purposes here to-day we may practically ignore the question of iron as giving color to the water. That part of the subject has been considered in great detail in some of the Boston Water Works reports, and owing to its complications need not be referred to here. It may be stated as a general rule that New England waters get their color from swamps.

Our investigations led us to the adoption of a scheme for draining the swamps, which was formulated in a report I made to Mr. Stearns and contained in the State Board of Health report on a Metropolitan Water Supply, 1895. It is rather interesting because it was something new in those days. The question to be solved was, What will be the effect on the color of the water if the swamps are partially drained? My estimate was that, by carrying out a certain system of draining and interception, the water would be reduced forty-two per cent. in color.

That system has been carried out on the Metropolitan Water Supply. I don't know exactly what the result has been on that part of the works which Mr. Richardson has charge of, but, on the part that I have particular charge of, the color has been reduced just about forty-two per cent., as far as I am able to say now.

Now, by filtration in the ordinary way in open filter beds, by the slow process of sand filtration, I have found by experiments during three years at the Chestnut Hill Reservoir, that, on the average, you can practically reduce the color of the water about twenty-five

per cent. I am not going to say anything about the chemical side of the question, because there are others here who can speak of that much better than I can. Now, it seems to me, Mr. President, considering that a gentleman is here with an admirable paper, which you are all anxious to hear, that I have said enough. If there are any questions that any one would like to ask, I would be happy to try to answer them, and perhaps some one would like to take up the matter and carry it along further.

I will say one word more on the question of storage. In this very arge reservoir at Clinton, which Mr. Stearns is building, I suppose the color of the water will be reduced to such an extent that it will practically not be noticed at all, because the water will be held in a large lake for about a year, and in that time almost complete decolorization is expected to take place. It has always been a delight to me to go to some large lake, like Lake Winnepesaukee, and see how absolutely pure in color the water is. But, if you walk around the shores of the lake, you will find the streams entering the lake are often very highly colored. The removal of this color is of course due to long storage, and that is what we are trying to do in building such large reservoirs, — to hold the water and store it long enough to get rid of the color as far as possible.

But it is not always practicable in small works. The resources for doing so are not always available, and I have sometimes thought that a good deal could be accomplished on some of these smaller works by turning some of the feeders on to large areas of gravel. I have seen situations where the erection of a small diverting dam would turn the water on to gravelly areas, through which it could percolate to the water tables below and then flow into the stream again, a very much whiter and purer water. I only throw that out as a suggestion. There are other ways. There are ways of turning a brook on to small areas of gravel and then sinking pipes and taking the water out from below. But I see I am getting into a very wide field, and so, thanking you, gentlemen, for your attention, and assuring you of my pleasure at being here with you again, I will give place to some one else. [*Applause.*]

The President. This is an interesting subject, gentlemen, and I trust it will bring out a full discussion. Mr. FitzGerald has referred in a word to the chemical side of the question. There is a gentleman present this afternoon who can perhaps give us some information from that standpoint, and I will ask Mr. R. S. Weston if

he will speak on the chemical side of the removal of color from water.

Mr. R. S. Weston. Mr. President, and members of the Association: This is the first meeting of the New England Water Works Association that I have attended for a year and a half, and I almost think that I am entitled to be allowed to enjoy it without interruption.

I have done a little work on the treatment of color in water, largely laboratory work, this last year in New Orleans. As you know, the Mississippi River comes down from the country above, bringing large quantities of silt and a large amount of vegetable matter, trunks of cypress and other varieties of trees. In the course of ages the whole delta on which New Orleans is situated has been built up in this way. If one bores a well about one thousand feet deep or less at New Orleans, one obtains water which has a color of from three hundred or four hundred to eight hundred or nine hundred parts per million. This water is quite alkaline. The treatment and removal of the color in it is something which is very difficult.

In the consideration of the question, namely, which would be the best source of water supply for the city of New Orleans, it was necessary, in order to satisfy certain elements of the population, to consider the question of an artesian well supply, and, in connection with that, one had to consider, more or less, the problem of the removal of this color from the well water. It was found that the only way to treat this highly colored water which is possible at the present time is to add sulphate of aluminum, allow the water to coagulate for some time, and then remove the cogulated masses by filtration. The ordinary colored water of New England — soft water — can be treated with about two to two and a half grains of coagulant to each gallon of water, for every one hundred parts per million of color to be removed. But in New Orleans we find that this ratio has to be multiplied several times in order to obtain the same result. The removal of color from water which is very alkaline, that is, which contains lime salts or sodium carbonate, is a matter of considerable difficulty. It is also found that if one neutralizes the alkali in the water before one adds the coagulant, a very much smaller amount of coagulant is necessary to treat the color. About the same amount of coagulant is required to remove the color of this water which has been neutralized as is required to treat waters in New England which need not be neutralized.

The following results of experiments made at New Orleans may be of interest: —

RESULTS OF EXPERIMENTS UPON THE DECOLORIZATION OF HIGHLY COLORED WATERS FROM DEEP WELLS AT NEW ORLEANS.

SAMPLE.	PARTS PER MILLION.		GRAINS PER GALLON OF SULPHATE OF ALUMINA.		
	Alkalinity.	Color by Platinum Standard.	To Decolorize		To Effect a Beginning in Color Removal from Original Water.
			Original Water.	Water after Neutralization.	
A	412	190	13	3.0	10
B	365	200	5	0.5	3
C	420	120	7	1.2	5
D	403	350	7	2.5	5
E	441	180	18	3.0	6

I think this subject of color removal is a very interesting one, and one which really ought to be studied in an experimental way somewhere and for some time. We have data now from all over the country with reference to suspended matter in streams, which are sufficient in almost all cases to enable an engineer to design a filtration plant which will meet the local conditions without much chance of failure. But the data necessary to design a plant which will remove color under all conditions successfully are not yet at hand.

One very peculiar thing about the color of the water, of the Southwest especially, is the way it is removed from solution by contact with suspended matter. I don't know of any other way to express it. For example, the water of the Yazoo Valley, and the water of all those small streams which empty into the Mississippi from Cairo down to New Orleans, is highly colored. It is more highly colored, perhaps, than that of any of our New England swamp waters, the flat nature of the country allowing a longer contact between the water and the organic matter contained in the swamps. When the water emerges from these rivers it is very highly colored, but in a short time after it has mixed with the Mississippi, along with the large amount of silt which is borne down from above, its color disappears entirely. The color is absorbed by the silt, and

the organic matter, which is found by analysis to be present in a dissolved state in the tributaries, is found in a suspended state in the water of the main river itself. The color of the Mississippi water, after the suspended matter is removed, is practically zero, while the color of these tributaries is as high as eight hundred or nine hundred units.

There is a misconception, I find, all over the country, with regard to the meaning of the terms "color" and "turbidity." I think it is best to consider the color as that which is not readily removed by straining. The vegetable stain or color is what produces the tea-like appearance of water, while the turbidity is that which offers resistance to the passage of light, — that is, suspended matter. Mr. Hazen and Mr. Whipple, as you all know, have bee lately doing some work for the United States Geological Survey, and have devised two very convenient, portable, and simple pieces of apparatus for determining color and turbidity. I will not attempt to describe these pieces of apparatus, for they will be described very soon in a bulletin of the Hydrographic Department of the Geographical Survey.* It is to be hoped that every superintendent of water works will get these pieces of apparatus and make observations of color and turbidity for the common good.

THE PRESIDENT. I will call upon Mr. C.-E. A. Winslow.

MR. C.-E. A. WINSLOW. I do not believe I can add anything to what has been said. I have been very much interested in what Mr. FitzGerald has reported about removing color by filtration through sand. From his results it would appear that the importance of that method of color removal has been underestimated. Considerable attention has been paid to the effects of storage and sunlight, but data with regard to the effect of filtration on highly colored waters are not abundant. The Lawrence filter, which effected a reduction of only 15.4 per cent. in 1893, falling pretty steadily to 8.3 per cent. in 1899, does not furnish a general precedent because the initial color of the water is so low. I hope that, somewhere, more experimentation will be done along this line and additional observations published.

THE PRESIDENT. The subject is now open for general discussion.

MR. F. N. CONNET. It is possible that Mr. Weston refers to the apparatus I am about to describe, and it has so many good features that it is well worth our attention. It consists of two aluminum

*Circular No. 3, Division of Hydrography, U. S. Geological Survey. — EDITOR.

tubes, each two hundred millimeters long, and fitted at each end with caps of clear glass. One tube is filled with the water whose color is to be tested, and the other is filled with distilled water. The latter tube has a little spring clip at one end for holding a disc of slightly colored glass. A number of colored glasses of various thicknesses is provided, and it only remains to select the proper thickness so that when the observer looks through both tubes simultaneously, the color will be the same. The glass discs are all numbered to correspond with standard platinum solutions.

When the water to be tested is highly colored, it is observed through a tube only one hundred millimeters long, and when it is still more highly colored it is observed through a 50-millimeter tube. Extremely high-colored water should be diluted a known amount before testing.

This device affords a convenient, portable, and unchangeable method of measurement, and there is no possible error as to the color of the standard, as there sometimes is when the solutions are made up with platinum salts from different manufacturers.

This device was perfected by Mr. Allen Hazen, of New York City, and I think he designed it originally for the United States Geological Survey.

PROCEEDINGS.

MARCH MEETING.

YOUNG'S HOTEL,
BOSTON, March 12, 1902.

President Frank E. Merrill in the chair.

The following members and guests were in attendance: —

MEMBERS.

L. M. Bancroft, E. C. Brooks, G. A. P. Bucknam, George Cassell, G. F. Chace, E. J. Chadbourne, J. C. Chase, J. W. Crawford, A. O. Doane, H. P. Eddy, J. N. Ferguson, Desmond FitzGerald, W. E. Foss, F. L. Fuller, Albert S. Glover, F. W. Gow, F. E. Hall, J. O. Hall, J. C. Hammond, Jr., H. G. Holden, J. L. Howard, J. William Kay, E. W. Kent, Willard Kent, C. F. Knowlton, A. E. Martin, W. E. Maybury, Frank E. Merrill, L. Metcalf, H. A. Miller, F. L. Northrop, J. B. Putnam, W. W. Robertson, C. M. Saville, E. M. Shedd, C. W. Sherman, H. O. Smith, J. Waldo Smith, G. A. Stacy, J. T. Stevens, H. L. Thomas, R. J. Thomas, W. H. Thomas, D. N. Tower, G. W. Travis, W. H. Vaughn, C. K. Walker, R. S. Weston, C.-E. A. Winslow, G. E. Winslow, E. T. Wiswall.

ASSOCIATES.

Builders' Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; M. J. Drummond, by Lester E. Wood; Hersey Mfg. Co., by Albert S. Glover; Henry F. Jenks; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by S. F. Ferguson; National Meter Co., by J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Norwood Engineering Co., by W. N. Hosford; Perrin, Seamans & Co., by James C. Campbell and Charles E. Godfrey; A. P. Smith Mfg. Co., by W. H. Van Winkle; Union Water Meter Co., by F. L. Northrop and C. L. Brown; United States Cast Iron Pipe and Foundry Co., by John M. Holmes.

GUESTS.

Nelson E. Bryant, Shanghai, China; W. H. Greenwood, Boston, Mass.; C. B. Russell, S. E. Jackson, A. F. Hall, George P. Hall, L. M. Hudson, Marlboro, Mass.; J. F. Gleason, Quincy, Mass.

The Secretary read the following names of applicants for membership, the applications having been approved by the Executive Committee: —

For Resident Member.

J. S. Chase, Hartford, Conn., Secretary Hartford Water Board; Samuel P. Senior, Bridgeport, Conn., Engineer and Superintendent Bridgeport Hydraulic Co.; William H. Hart, Bridgeport, Conn., Assistant Engineer, Bridgeport Hydraulic Co.

For Non-Resident Member.

William G. Raymond, Troy, N. Y., Consulting Engineer on new supply works, Troy, N. Y.; Carleton E. Davis, Upper Montclair, N. J., Engineer in charge of construction of new storage reservoir, Newark, N. J.

On motion of Mr. Fuller, the Secretary was directed to cast the ballot of the Association in favor of the applicants, which he did, and they were declared duly elected members of the Association.

The first item upon the program was a paper by H. W. Clark, Chemist of the Massachusetts State Board of Health, on "Investigations in Regard to Coloring Matter in Water and Methods of Removal." President Merrill announced with regret the receipt of a telegram from Mr. Clark announcing his inability to be present on account of illness, and called upon Mr. Desmond FitzGerald to address the meeting upon the subject-matter of Mr. Clark's paper. Mr. FitzGerald responded with an interesting contribution, and he was followed by Mr. R. S. Weston, — who spoke particularly of certain recent work in New Orleans, — Mr. C.-E. A. Winslow, and Mr. F.N. Connet, who described a portable device for color testing.

Mr. Caleb Mills Saville, Division Engineer, gave a description, illustrated by the stereopticon, of the work of the Metropolitan Water and Sewerage Board in the construction of reservoir and standpipe at Forbes Hill, Quincy, Mass.

The Committee on Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto was not ready to report, but a certain amount of progress was reported, and it appeared that the Committee is going into the matter with a good deal of thoroughness.

Adjourned.

Meeting of the Executive Committee.

715 Tremont Temple,
April 17, 1902.

The Executive Committee met at 10 A.M., President F. E. Merrill in the chair, and present, also, Messrs. L. M. Bancroft, C. W. Sherman, W. B. Sherman, H. O. Smith, R. J. Thomas, and Willard Kent, Secretary.

On motion of Mr. Thomas it was voted: That the President and Secretary be empowered to renew the lease from the Boston Society of Civil Engineers of the rooms in Tremont Temple, on terms at least as favorable as those of the present lease.

The choice of a place for the Annual Convention was the next business. The Secretary reported the result of the expression of opinion from members, as shown by the return postal cards, as follows: —

	Members.	*Associates.*	*Total.*
Boston,	110	15	125
Atlantic City,	84	6	90
Montreal,	70	14	84

After discussion, the Executive Committee voted unanimously in favor of holding the Convention at Boston.

It was voted: That the President, Secretary, Treasurer, and Advertising Agent, with Mr. Harold L. Bond (Associate), be a committee with full powers to make all arrangements for the Convention.

Adjourned.

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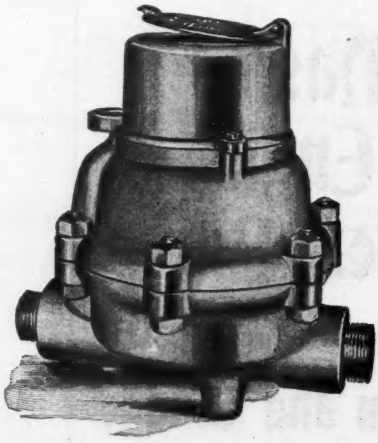

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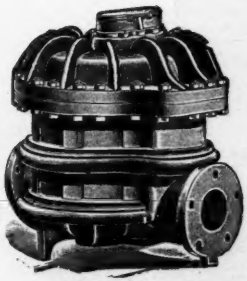

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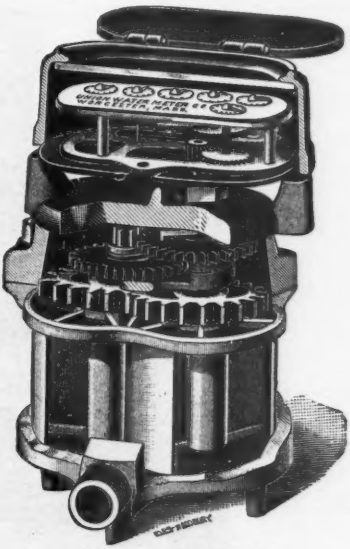

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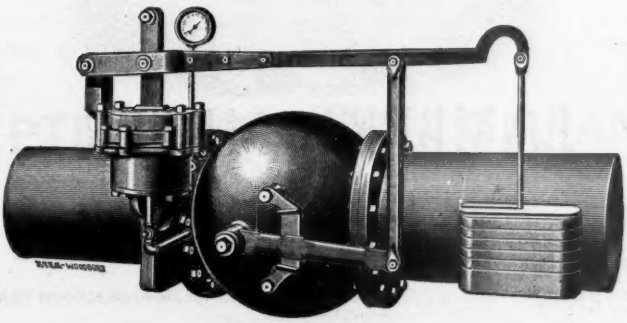

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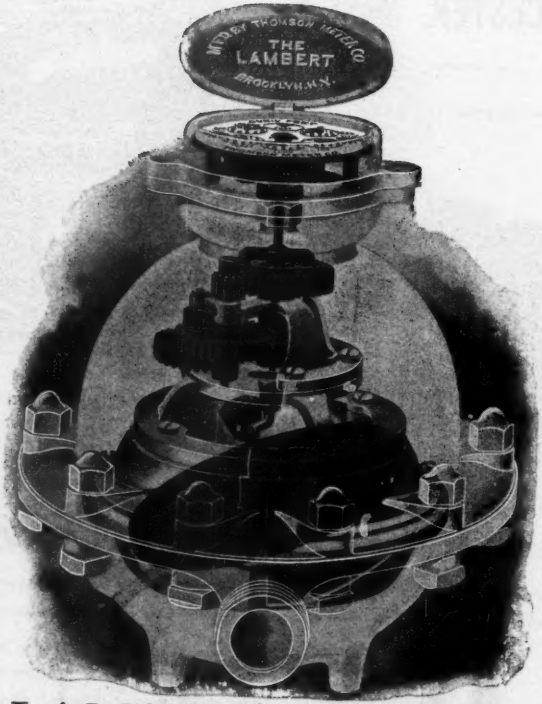

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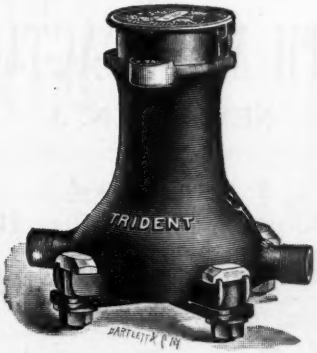

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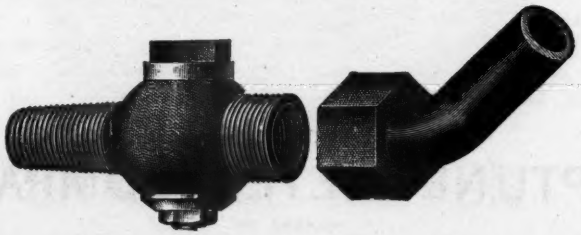

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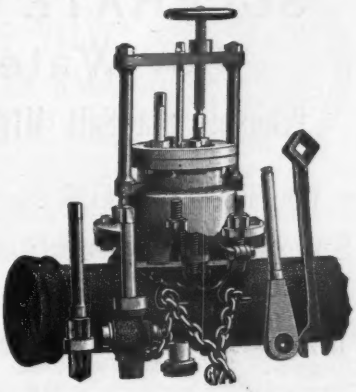

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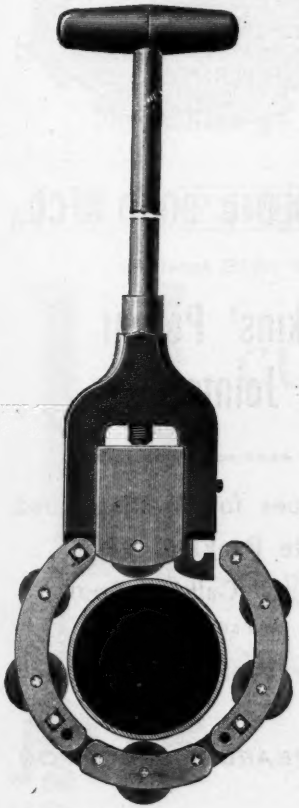

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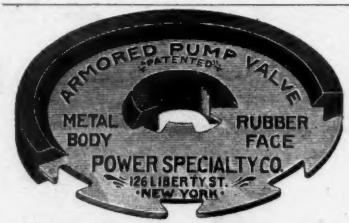

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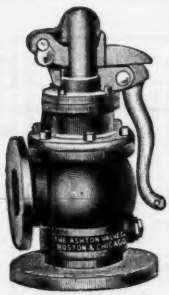

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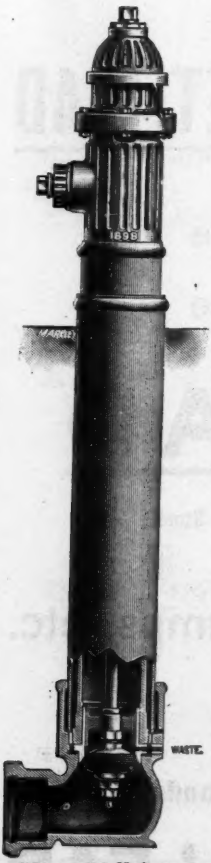

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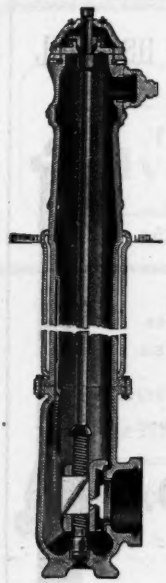

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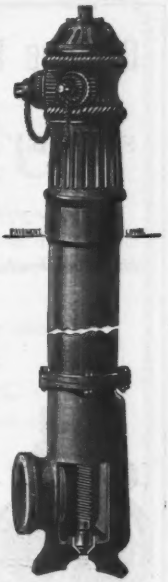

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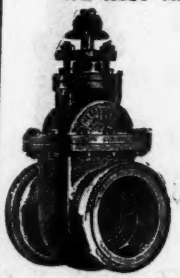

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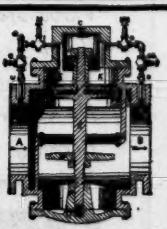

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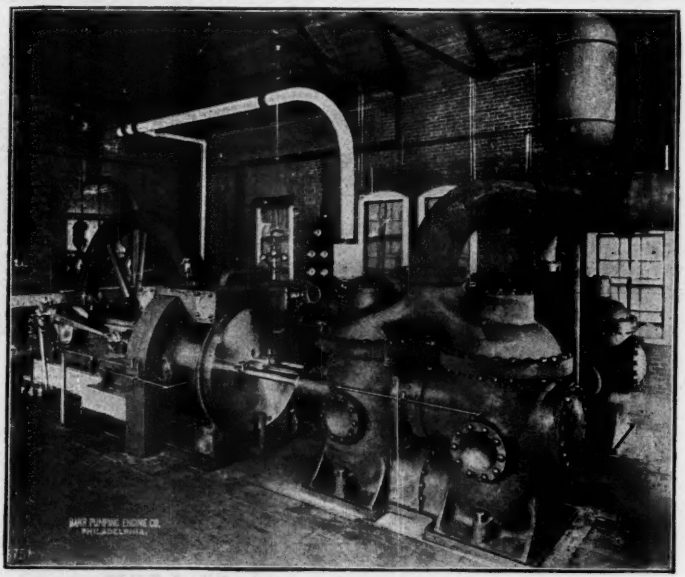

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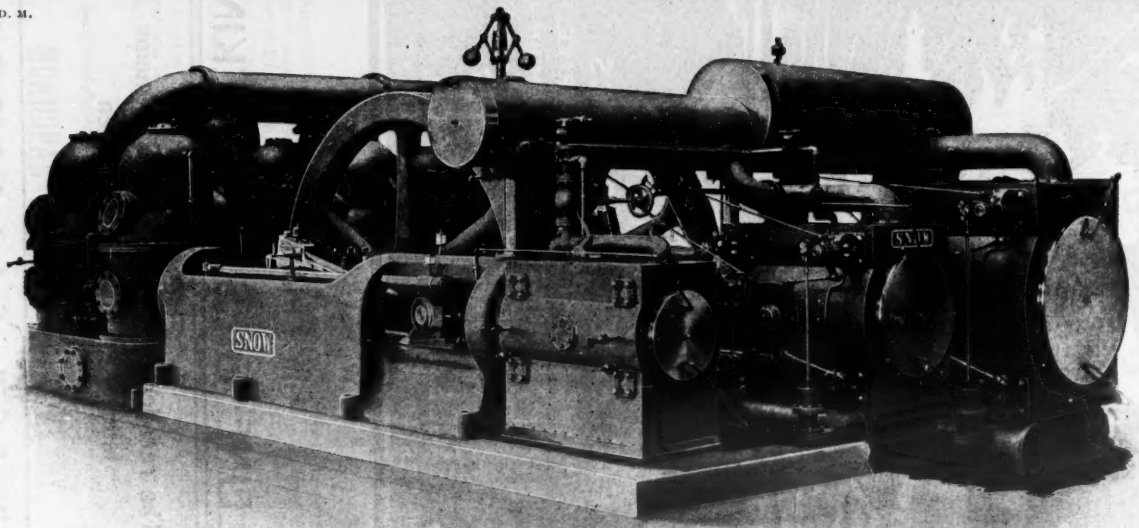

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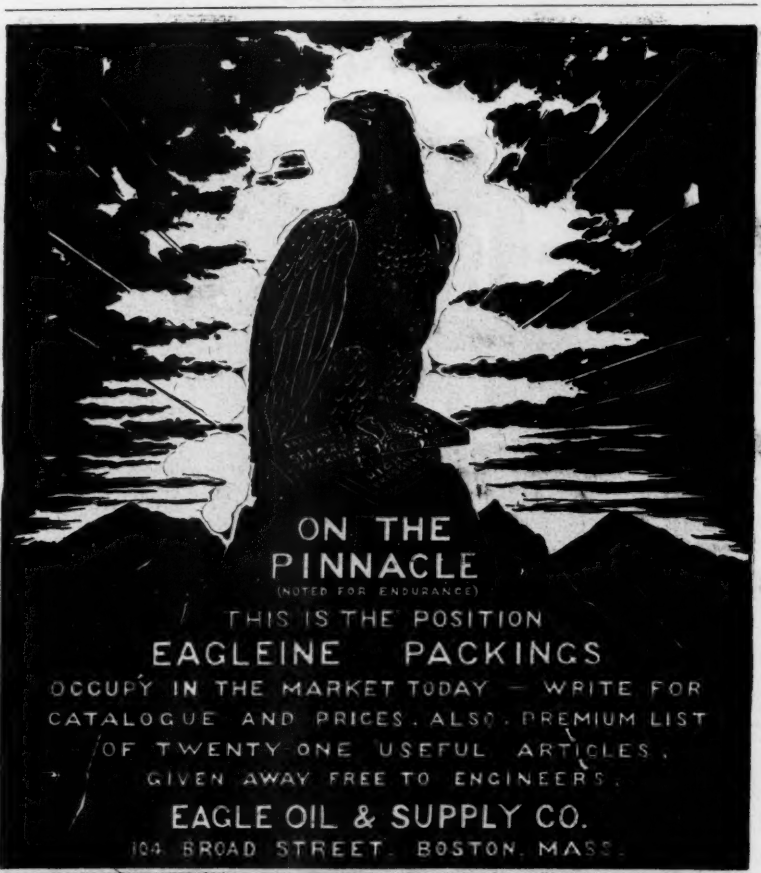
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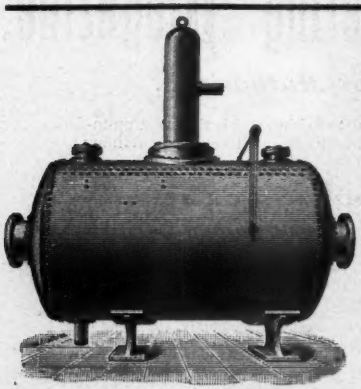

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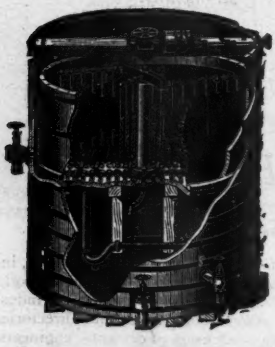

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KEITHSBURG, ILL.,
October 23rd, 1899.

The National Paint and Varnish Company,
Manufacturers of Graphite Paints and Varnishes,
Cleveland, Ohio.

GENTLEMEN:

Your letter of the 8th is at hand, acknowledging receipt of the money sent you in payment for the paint purchased of your agent, that we painted our Stand Pipe with. Will say that we painted the stand pipe inside and out with your paint. So far it has given very excellent satisfaction. It has the body, together with the staying qualities, and to any one needing a paint for iron or steel, must say that they could not do better than to purchase your paint. In conclusion, will say that we have not had one complaint from the water being tainted by the paint since the water was turned on after finishing the painting, and we did not give it much time after the paint was put on. Hoping that you will have good success with your paints, as you deserve it, we remain,

Yours truly,

Approved: TOM A. MARSHALL,
Mayor.

Attest:
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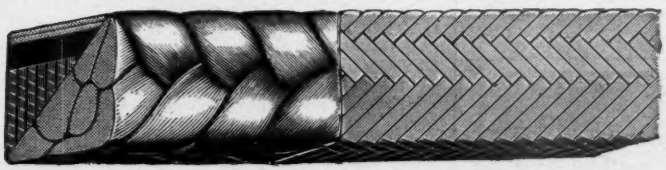

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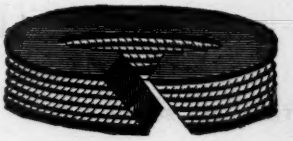

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